FIRST

ANNUAL REPORT

OF

SAPPORO

AGRICULTURAL COLLEGE,

1877.

TOKEI
PUBLISHED BY THE KAITAKUSHI.


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INDEX.

ANNUAL REPORT.

His Excellency

KURODA KIYOTAKA,

Minister of the Colonial Department.

SIR,—I have the honor to present for your consideration the First Annual Report of Sapporo Agricultural College, which was formally opened by Your Excellency on the fourteenth of August last.

It has been well said "A country is nothing without men, men are nothing without mind, and mind is little without culture. It follows that cultivated mind is the most important product of a nation. The products of the farm, the shop, the mill, the mine, are of incomparably less value than the products of the schools. If the schools of a people are well taught, all else will prosper. Wherever schools are neglected it is a sure sign of national degradation and decay. The central point of every wisely administered government is its system of education. The education of youth well cared for by a nation, out of it will grow science, art, wealth, strength, and all else that is esteemed great in the judgment of men." A profound respect for learning has long characterized the more cultivated nations of the East, but never

has greater enthusiasm in the pursuit of useful knowledge and the establishment of educational institutions been manifested by any people than by the Japanese under the intelligent government of His Imperial Majesty Mutsuhito. Actuated by this spirit, Your Excellency has founded the Sapporo Agricultural College at the capital of your vast province of Hokkaido in order that the young men who are educated for officers may become familiar with its climate, soil and resources, and be qualified to aid efficiently in the development of its various productive industries. Though it contains exhaustless supplies of valuable timber and excellent coal, marble and other minerals, and though the salmon, herring, cod and other fisheries are of immense value, if properly conducted, yet the greatest wealth of the province is to be derived from its fertile soil. Agriculture is the surest foundation of national prosperity. It feeds the people, converts the elements into property, and furnishes most of the material for manufactures, transportation and trade. The business of a country can be most profitably done by resident citizens who are intelligently and earnestly devoted to its welfare, and they alone can be relied on for its defense in time of foreign invasion. As soon as practicable, therefore, the migratory fishermen of Hokkaido should be converted into permanent settlers.

The agriculture of Japan greatly needs improvement, and the value of its agricultural products should soon be largely increased. The most important step forward consists in the general introduction and use of domestic animals of suitable breeds. These are necessary for a great variety of purposes. Horses

and oxen are required for farm labor and for draft, good milch cows for dairy products, beef, veal and hides, sheep for wool and mutton, and swine for lard and pork. The food thus produced should be chiefly consumed by the people for the increase of their comfort and ability to labor; but if they do not desire it, it may be exported to foreign countries and exchanged for gold or other desirable articles. The wool is needed for the manufacture of cloth and the hides for leather, of which at present there is no adequate supply. An active, energetic people cannot long be contented with clumsy wooden clogs. Moreover, a scientific agriculture should both increase the products and improve the fertility of the soil, and this can only be accomplished in a large way by the abundant use of fertilizers, the most useful of which for all purposes is the excrement of farm animals.

The general use of horses and oxen would necessitate the manufacture of harnesses, vehicles, and agricultural implements, and so give employment to a great number of artizans. It would also enable farmers possessing teams to cultivate much more land and to do it more economically than under the old system.

A proper mode of feeding would require the extensive cultivation of Indian corn and foreign grasses, which are the most abundant and profitable crops of the northern portion of the United States. Thus the annual hay crop from cultivated grasses in the state of New York is worth more than fifty million dollars, and the corn crop of Illinois amounts to one hundred and thirty million bushels per annum. The value of the domestic animals in the United States is more than fifteen hundred millions of dollars, and the

value of those annually sold or slaughtered for food is not less than four hundred millions. Besides this immense sum derived every year from live stock, the country is enriched by the labor of many millions of horses, mules and oxen, which is worth at least three hundred millions of dollars per annum. To this should be added the value of one hundred million pounds of wool, five hundred million pounds of butter, fifty million pounds of cheese and five hundred million gallons of milk. When now it is considered that all these sources of agricultural wealth are practically ignored in Japan, it will be readily admitted that there is room for improvement.

But Your Excellency has appreciated the importance of introducing domestic animals, and already a successful beginning has been made in breeding horses, neat cattle, sheep and swine at the agricultural establishments of the Department at Sapporo and Nanaye. The difficulties, however, in the way of rapid progress are by no means inconsiderable. The natural vegetation of Hokkaido is rank and coarse, and well suited neither for pasturage nor hay. Experience in America shows that while the natural grasses of the country are in some instances of excellent quality, yet in almost all cases, it is necessary for success in stock raising to depend chiefly upon cultivated plants for winter feeding. While, therefore, wild Hokkaido hay may be often profitably employed, especially if reduced to chaff and steamed, it is nevertheless very essential for progress that forage plants be introduced as rapidly as possible. In like manner it may be wise to use for fodder beans, barley and rice bran, but the main dependence for grain for stock in Hokkaido should be upon Indian corn, for which the soil

and climate are very favorable, at least about Sapporo.

Another obstacle in the way of successful stock-raising is found in the poverty of the farmers and their wretched modes of building. Well-bred animals, which are the most profitable, could hardly survive the winter storms with such shelter as the country people deem sufficient for themselves. Good barns, therefore, are required for the protection of animals, crops and manure from the injurious effects of the weather. Your Excellency has so clearly apprehended this fact as to order the erection upon the College farm at Sapporo of a model barn, the plan adopted being a slight modification of the one used on the estate of the Massachusetts Agricultural College.

LOCATION OF THE COLLEGE.

The city of Sapporo is situated on a fertile plain in the valley of the Ishcari River. It is the capital of the province of Hokkaido and contains about eight thousand inhabitants. Its streets are broad and straight, crossing each other at right angles in the direction of the cardinal points; but the buildings are mostly in the Japanese style, which is unsurpassed for economy both of taste, convenience and construction. There are, however, several confortable tenements erected by the Government for its officers, and the public buildings are in foreign style. The capitol is a somewhat imposing structure surmounted by a dome-like cupola from the flag-staff of which floats the blue flag of the Colonial Department, in the centre of which is a five-pointed red star. This edifice is situated in the north-east portion of the city and is

about seventy-five feet above the level of the sea. Its latitude is 43° 3′ 54″ north, and its longitude is 141° 22′ 5″ east from Greenwich. The distance from Sapporo to the Japan Sea is about ten miles. West of the city lies a mountainous region, extending many miles to the west and south, which is covered with excellent timber, and from which flow several beautiful streams. The highest peak is about eight miles from the capitol and has an elevation of 2,950 feet. It is called Mt. Tiene and affords a charming view in all directions. A rapid mountain stream, named the Toyohira, runs through the eastern portion of Sapporo and furnishes ample water power for a large number of manufactories, as well as an abundant supply for the use of the city and for the irrigation of the College farm. An excellent wooden truss bridge, three hundred and fifty feet long, connects the two banks of the river and forms a portion of the great highway between Sapporo and the east coast. This road constitutes the direct route to Mororan and Hakodate, the latter city being about one hundred and fifty miles distant.

The Ishcari is one of the largest rivers of Japan and in its broad valley are immense areas of fertile alluvial soil. In its lower portion the river is about seven hundred feet wide and twenty feet deep, and not only are its waters navigable, but they abound in salmon and other valuable fish. In the upper portion of the valley are exhaustless beds of excellent bituminous coal, plenty of valuable lumber of many sorts and beds of handsome marble and serpentine. The region drained by the river has only been partially explored, but enough is known to render it certain that it is admirably adapted for the support of a large and prosperous popu-

lation. The distance from Sapporo to the river is about eleven miles.

The climate of this portion of Yesso is salubrious and agreeable, and favorable to the production of all the crops which are grown in the Middle States of the American Union. While the south-eastern portion of the island, with a coast line of several hundred miles, has so little snow in winter that large numbers of horses run wild, receiving neither food nor shelter, yet in the western and northern parts snow is very abundant, though the cold is moderate. At Sapporo during the past winter the ground has been so well protected by its white, fleecy blanket since November twelfth that it has not frozen at all, so that a large amount of ditching, grading and fence-building has been done. The mildness of the winters is unmistakably shown in the character of the vegetation, which is exceedingly like that of Virginia. The mistletoe and several species of *Magnolia* are everywhere abundant, while the gigantic woody vines are so numerous and luxuriant as to remind one of a tropical country. A specimen of wild grape vine found in Sapporo and now in the College museum is eleven inches in diameter. There are two or three species of *Ampelopsis* and *Vitis* which make a handsome appearance in summer, and their autumnal foliage is of a brilliant scarlet. A *Rhus* equally beautiful, but very poisonous, attains a diameter of six or eight inches and a height of eighty feet or more, while a *Celastrus*, resembling *scandens*, grows nearly as large. Allied to this, and even more ornamental with its showy fruit, is the evergreen *Euonymus radicans* which attaches itself by aerial rootlets firmly to the bark of trees and ascends to the height of from forty

to sixty feet. But the largest and most remarkable climbers are a *Schizophragma* with the fine foliage and flowers of a *Hydrangea*, and an *Actinidia*, one of the *Camelliaceae*, interesting both for its vigorous habit and the grotesque forms of its immense twining stems, and also for its elegant foliage, its charming flowers and its palatable fruit.

THE COLLEGE BUILDINGS.

The buildings containing the lecture rooms, library, chemical laboratory and dormitories are well located on a square in the northern portion of the city, directly in front of the capitol. The soil is level and fertile and easily irrigated by water from the Toyohira. The area is fourteen acres and affords ample room for the necessary buildings, and a most excellent site for the Botanic Garden, to which it has been assigned. It is surrounded by an embankment of turf with a ditch on either side in true Japanese style.

The frontispiece gives a correct idea of the front or western view of the College square. The buildings are constructed of wood and, though not above criticism, are neat and convenient, and under the circumstances of the country, highly creditable to the officers who have erected them. The want of chimneys is a singular feature and betrays the southern origin of the builders, while the lowness of the central building and the great extent of ground covered to obtain rooms for a few students, indicate the work of a native architect.

The north building on the extreme left of the frontispiece is seventy feet long by thirty feet wide with an L in the rear thirty feet long by eighteen feet wide, and is occupied by lecture rooms, cabinets and

offices. Another L thirty-five by twenty-five feet, is utilized for servants, clothing, privies and fuel.

The low building in the centre of the picture is one hundred and ninety-two feet in length by forty in width, and is chiefly used for dormitory rooms, which are fifteen feet square. A similar structure parallel with this and thirty-three feet in the rear, furnishes rooms for a dining-hall, kitchen, bath-room and servants' quarters with necessary store rooms and offices. The two-story building on the right is connected with the dormitories, and is used for a lecture-room and a public study-hall. These rooms are about forty by twenty-seven feet and are very well lighted and ventilated. The entire establishment will comfortably accommodate from fifty to sixty students.

The new library is a small two-story building between north college and the dormitory.

The new chemical laboratory is a two-story building, forty feet square, and located one hundred feet east of the study-hall. It contains in the basement a store-room for supplies, and rooms for packing materials and fuel. The lower floor is occupied by the general laboratory for students, the room for quantitative work, and the balance and furnace-rooms. On the second floor are the lecture and apparatus rooms, and the rooms for collections in mineralogy and geology, and in chemistry. The entire arrangement and equipment of the building are in accordance with plans prepared by Prof. D. P. Penhallow. The cost of the laboratory, with furniture and chemicals for the first year, was about eight thousand dollars.

THE COLLEGE FARM.

The mountains west and south of Sapporo consist of volcanic tufa and sandstones which have been more or less modified by heat. The tufa is easily worked and may be obtained in blocks of any desired size, but the sandstone is usually hard and much broken by seams. There can be little doubt, however, that excellent quarries might be opened, if there were a suitable demand for stone. It cannot be long before the present shiftless practice of erecting houses and other buildings without either cellars or chimneys upon wooden foundations will be abandoned, and the rocks applied to their legitimate uses.

The soil of Sapporo consists of a very fine, black earth about a foot in depth, resting on a diluvial formation of very variable materials. Sometimes it is a yellow loam, sometimes loose sand, and again beds of gravel and small pebbles and cobbles of volcanic silicious rock. Specimens of both the soil and subsoil have been collected for chemical analysis, but unfortunately the results cannot be obtained for this Report, owing to the delay in finishing the laboratory. The large size of the oak and elm trees standing upon it and the extraordinary annual growth of the herbaceous plants, *Senecio palmatus*, often attaining a height of twelve feet, give indubitable proof of the agricultural excellence of this virgin soil. The ground has generally a gentle slope towards the Ishcari or the sea, though the banks of the streams are usually higher than the adjoining country so that the drainage is away from them. In times of freshets the singular phenomenon is exhibited of rivulets running away from the large streams into the lower lands. The soil

is very smooth and entirely free from stones. The roots of the forest trees are mostly in the mellow soil near the surface, so that the stumps are removed with remarkable facility. This peculiarity of the root system of all the trees of Yesso is doubtless caused by the abundant moisture which renders deep roots unnecessary, especially in the forests, which cover most of the country.

The College farm lies immediately north of the capitol grounds and contains two hundred and fifty acres. Of this area about one hundred acres consist of most admirable tillage land in perfect condition. Last year it produced fine crops of herdsgrass, clover, wheat, barley, oats, rice, beans, Indian corn, Chinese indigo, potatoes, flax and hemp. About one hundred acres of wild land of excellent quality are devoted to pasturage, and the remaining fifty acres are covered with timber. Within less than one hundred feet from the barn flows a clear stream ten feet wide, which never freezes.

Having been duly appointed Director of the College farm with the absolute control of its management, and with the sole responsibility for the wise expenditure of the liberal sum of fifteen thousand, three hundred and fifty dollars appropriated for its general expenses, I entered upon the discharge of my duties on the eleventh of October, 1876. His Honor Vice-Governor Hori, to whom I was referred by Your Excellency for the adjustment of several important matters relating to land, live-stock and implements, treated me with great kindness and arranged every thing to my satisfaction.

Officers Hori Seitaro and Yoshida Kiyonori having been assigned to duty at the farm, the former as

secretary and interpreter, and the latter as superintendent, the work of improvement was vigorously begun. Requisitions were made and granted for ten horses, four working bulls, and nine Shorthorn cows and heifers and one bull. All necessary vehicles, machines and implements for the farm were also furnished at once or ordered from America. Fifty bushels of seed corn and fifty bushels of grass seed including all the most important kinds were at the same time purchased in Massachusetts and have already arrived in Sapporo.

With the aid of Professor Wheeler the farm was surveyed and a map prepared, which was approved at the capitol. As the old fences were very poor and the boundary lines very crooked, it was determined to run straight lines wherever it was practicable, and to enclose the entire farm with a new fence. After a careful inquiry into the cost of material and labor, I concluded to build by contract a fence of the following description, which is admirably suited to a country where timber is plenty and the ground sufficiently soft. For swampy lands it can hardly be surpassed. Oak stakes, six feet long for the upland and six and a half for the meadows, were sharpened and set one foot apart on the line. They were then driven into the earth with heavy mauls so as to stand four feet high. The stakes are six inches wide and two or three inches thick and firmly secured at the top to long strips of oak, which are three or four inches in diameter and overlapped at the ends so as to form one continuous rail. Every stake is fastened to the rail by a loop of a grape or other vine about three quarters of an inch in diameter, long pieces of vine being wound back

and forth as far as they will reach, and the ends being firmly fixed so as to prevent unwinding. The vines were made more pliable by placing the coils as they were brought from the forest upon fires built for the purpose. As soon as they became hot the sap in the green wood was converted into steam and softened the woody fibre. The contractor furnished all the materials and put up this fence in a most satisfactory style for thirteen and a half cents per ken, which is equal to about thirty-seven cents per rod. The total amount required to enclose the farm and pasture was more than three miles.

The next improvement demanding attention was the opening of ditches to carry off the surface water which accumulated in certain portions of the tillage land, and to prevent water from the woods on the eastern boundary from entering the cultivated fields.

After a thorough survey with a level it was decided to open a broad, shallow water course from the street on the southern boundary through the centre of the tillage land to the pasture on the north, a distance of about one mile. Accordingly with the aid of a plow and scraper the ditch has been dug most of the way, with a width of five feet at the top and a depth of from one to three feet as the level of the surface required. Besides serving to drain off the surface water in spring and after heavy rains, this ditch will be of great use as the outlet of the water which it is proposed to introduce from the Toyohira for irrigation. In this way the grass crop can be largely increased and rice and cranberries grown in a most successful manner.

About one hundred rods of ditch, two and a half feet wide at the top, and two feet deep, have been dug by contract during the months of December and

January, although the snow was three feet in depth. This ditch runs along the border of the woodland and cost four cents and nine mills per ken, or about thirteen and a half cents per rod.

In order to render the use of machinery practicable all the roads and ditches with which the southern portion of the farm was intersected have been obliterated, and the twelve hundred small fruit trees of American varieties, which were set along their margins, have been removed to a plantation by themselves where they will receive every attention and soon come into bearing.

A suitable gate has been erected near the old entrance from the street, and a new road will be laid out in the spring to the office and barn. For the construction of this road a large amount of gravel has been brought during the winter from the bank of the Toyohira. In this way the men and teams have been furnished with exercise, and have earned something to defray the cost of their maintenance.

In feeding out the coarse, hard stuff called Hokkaido hay, which seems to consist of nearly every variety of herbaceous plants except sweet grasses, and which is cut only when ripe and usually after frost, and left exposed to wind and rain till it is perfectly convenient to gather it, we have adopted the plan of steaming it, by which it is rendered more palatable as well as digestible. A tight box six feet square and three feet deep is filled with hay, cut into pieces an inch or two in length, and with this are mixed hot boiled beans and barley and sufficient boiling water to moisten the mass. The whole is then covered carefully and allowed to stand several hours, when both horses and cattle will eat a large proportion of what is given them.

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SAPPORO AGRICULTURAL COLLEGE BARN.

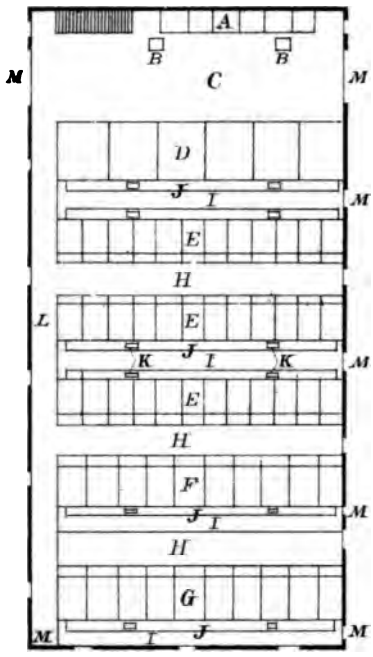
This method of feeding is, however, both expensive and inconvenient, and involves the risk of loss by fire, against which the people here have not yet learned to take suitable precautions. Pipes, paper lanterns and open fires of charcoal and wood, are unsafe companions in a barn. It is proposed hereafter to have them all excluded from the College barn, and to feed the stock on well-cured hay from cultivated forage plants with the addition of rice-bran, corn-meal and roots, none of which will require cooking.

THE MODEL BARN.

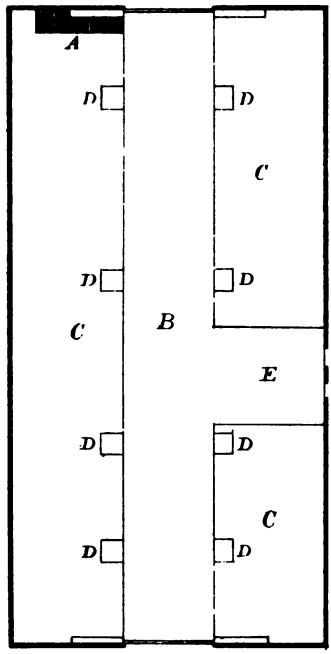
The proper construction of farm buildings has been made the subject of much study and numerous experiments both in Europe and America. Where domestic animals require food and shelter for half the year, commodious barns are among the indispensable wants of a successful agriculture. The roof is one of the most important, the most perishable, and, therefore, one of the most expensive parts of a building. It is consequently wise to plan for bringing as much as possible under the roof and so reducing it to the smallest practicable dimensions. The next point demanding consideration is convenience, or economy of labor. That barn is clearly the best, other things being equal, in which the necessary work can be done by the fewest men and in the least time. Finally, as manure is essential to any rational system of farming, abundant provision should be made for its manufacture and preservation. With these principles in view a design for a model barn for the College farm was prepared, and plans and specifications in accordance therewith furnished by Professor Wm. Wheeler. He also made an isometric drawing of the frame in Amer-

ican style by which a great saving of timber and labor is effected in the construction, and a better building secured than is possible in the Japanese mode of framing. The working plans were skillfully drawn by Mr. Adachi, the chief carpenter of the Department, who manifested much interest in learning how the work was to be done and in superintending its execution.

In order that the barn may serve as a model for imitation, with suitable modifications according to circumstances in different parts of the Empire, it will be described somewhat in detail. The general appearance of the exterior may be understood from the accompanying view, which is taken from the north-east. The building is one hundred feet long by fifty feet wide, and the height of the posts from the ground to the eaves is twenty-five feet. It is covered with spruce boards and battened with strips two inches wide, while the roof is of sawed spruce shingles. The foundation walls are built of seasoned oak and elm logs twelve inches square and of various lengths, which are laid horizontally one upon the other and securely held in place by dowels, joints and headers. The manure cellar A in the plan is eighty-four feet long, fifty feet wide and nine feet deep in the clear. B is a yard for swine, which is thirty-four by twenty feet. It is intended that a considerable number of swine shall be allowed to run on the manure in the cellar and to enjoy the sunshine and fresh air in the yard, which may also be connected with a pasture immediately in the rear of the barn. C is a root cellar forty-five feet long and sixteen feet wide. Roots may be dumped upon slatted screens in the form of an A through trap-doors in the floor of the drive-way in



Stock Floor.



Hay Floor.

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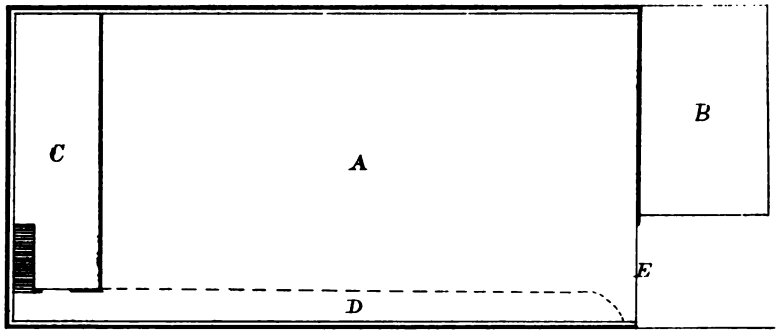


Cellar.

AGRICULTURAL COLLEGE BARN.

the first story. The screens will break the fall of the roots and prevent bruises, as well as separate much of the earth which may have adhered to them in the field. D is an elevated walk through the manure cellar five feet in width. E is the drive-way into the cellar and is sixteen feet wide and closed by doors hung at the top on iron rollers. The manure cellar is well lighted and ventilated by windows in the west end and also on the north side, and the root cellar is ventilated by flues extending to the roof. A flight of stairs connects the cellar with the story above.

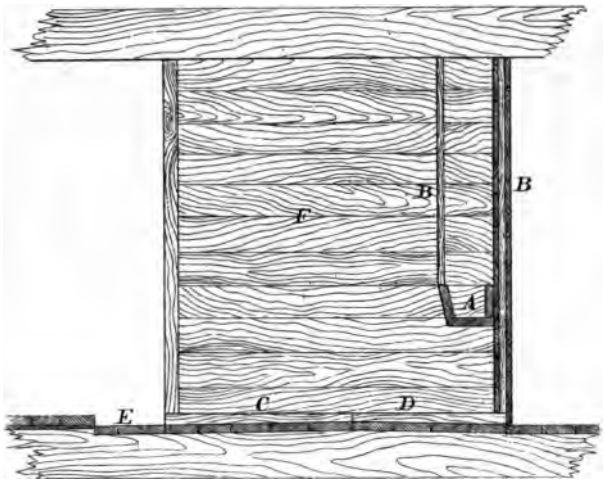
The first floor above the cellar is devoted to the stalls and boxes for horses and neat cattle. It is so arranged that the stock can all have easy access to the barn-yard, which is on the south side of the building and is one hundred feet square.

On the east side of the yard is to be an open shed forty feet long and twelve feet deep, with posts twelve feet high, for the shelter of stock running out of doors. The east side of this building, which is to be thirty feet in width, will be on a line with the front of the barn to which it will be connected, and will afford convenient shed room for carts and wagons.

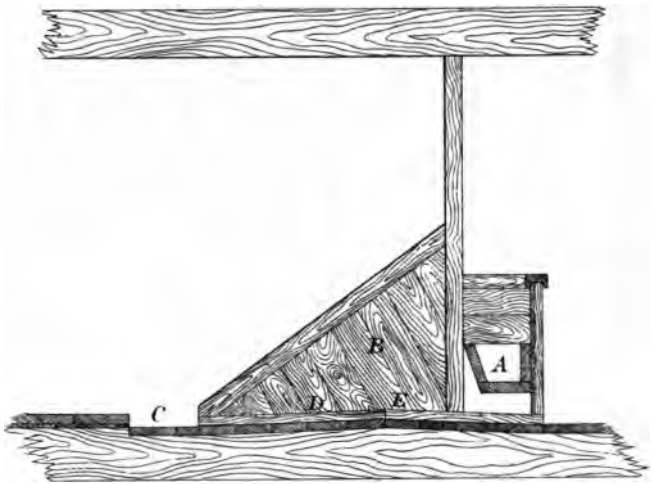
Upon the north side of the barn it is proposed to erect a wing sixty feet long and thirty feet wide with posts fourteen feet in height. The west side of this building will be on a line with the west end of the barn. In the lower story will be pens with yards adjoining for bulls, young cattle, sheep and breeding or fattening swine, while the upper story will furnish room for twenty tons of hay or straw.

In the plan of the stock floor A represents grain bins four feet square, and in a line with the stair-case from the story above. B is a trap-door two feet square

in the floor of the drive-way C, which opens into the root-cellar. D indicates the box stalls of which there are six, each nine by six feet. The partitions extend from the floor to the ceiling on three sides of these so as to prevent animals from disturbing each other. E is a row of twelve cow stalls, which are each three feet two inches wide. The length of the floor of one row of stalls for large animals is five feet eight inches, while in the other two rows of twelve each it is four feet eight inches. The mode of construction may be understood by reference to the drawing of a section on another page in which A is the manger of two inch plank along the whole front of the stall. The bottom of the manger is eight inches from the floor. B shows a partition which is four feet high in front and slopes to the floor in the rear. The stalls are all separated in this manner. C shows the manure gutter eighteen inches wide and three inches deep, extending along the rear of all the stalls. D and E represent the floor planks sloping one and a half inches each way from their line of junction, which is two feet back of the front of the manger. The slope of D is to carry off the urine and that of E is for the comfort of the animal in standing. H in the plan of the stock floor is a passage way four feet ten inches wide for feeding, the hay being thrown down through trap-doors in the floor above. The partition between the passage way for hay and the mangers is three feet high. To prevent the animal from getting hay under his feet boards are fastened obliquely from the top of the stall partitions to the centre of the front of the mangers. The mangers of the several stalls are separated by partitions. The cattle are to be secured by chains or straps attached to holes in the oblique



Horse Stall.



Cow Stall.

Scale: $\frac{1}{50}$

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boards on the front of the mangers. F represents a row of ten stalls for working oxen or bulls, which are four feet wide and five feet eight inches long. G is a similar range of ten horse stalls constructed as shown in the section represented. A shows the manger of oak plank, two feet from the floor. The front is boarded up to the ceiling; a space twelve inches wide and extending also to the ceiling, being left for the horse to feed through. The food is put into the manger through an opening twenty inches square in the partition B, which separates the stall from the passage way H. The opening for feeding is a sliding-door of oak bars, which will admit light and air but will prevent the horse from tossing his food out of the manger. C and D represent the floor, which is the same as in the cattle stalls and is very important in the horse stalls to obviate unnecessary tension of the back sinews. E is the manure gutter, and F, the partition extending to the ceiling.

Reverting to the plan of the stock floor, I indicates a passage way, J, a manure gutter, K, a trap-door opening into the cellar, L, a passage-way five feet wide, and M, a door. There are four doors three feet in width opening into the barn-yard, and a door eight feet wide at each end of the drive-way C. Ventilation for this story is secured by having the windows hung with weights so as to let down at the top. The posts of the lower story are eight feet high, while those of the upper one are seventeen feet.

In the plan of the hay floor, A shows a covered staircase leading to the stock floor, B, a driveway or threshing floor extending through the whole length of the barn, C, a bay for hay, the partition between which and the floor is three feet high. D marks a trap-

door which opens over a passage-way in front of a row of stalls in the story below for throwing down fodder, or straw for bedding. E is a square space near the centre of the barn which will not only admit light and air through its two windows, but also serve as a convenient place for keeping tools and machines. The two large doors at each end of the driveway are hung on iron rollers and each door is thirteen feet high and eight feet wide. Over the drive-way is a moveable scaffold which will contain a large amount of corn stover, straw or other coarse material. Over each door-way is a long window about twenty inches high and sixteen feet in length. This story is well ventilated by windows at each end and by the cupola on the roof, which is furnished with a trap-door opened by a cord from the drive-way. This hay story will contain more than one hundred tons of hay which is to be unloaded and stowed away by means of a horse-fork. The whole arrangement of the barn is such as to economize manual labor as much as possible. The fodder is lifted to the place of stowage by horse-power and then has only to be thrown down into the drive-way, whence it is pitched down to the stock floor, where it is fed out. The manure is then dropped into the cellar below, where the solid and liquid portions are both preserved at a uniform temperature, and prepared for use in the field by the rooting and trampling of swine, and such manipulation as may be found desirable. A well graded road from the cellar renders it easy for teams to go in and out as required.

The level character of the location rendered it necessary to construct an inclined drive-way at each end of the barn as seen in the elevation. The one on

the east end or front is two hundred and fifty feet long and rises about five feet in a hundred. It was constructed with the earth taken from the excavation for the cellar and is twenty-five feet in width at the top. It is built straight from the barn for fifty feet and then turns at right angles to its first course and extends two hundred feet to the south. The driveway at the rear of the barn is built of timber and turns to the north as represented.

The office of the farm superintendent with rooms for the teamsters is about one hundred yards south of the barn. The building is one hundred feet long and thirty feet wide with posts twelve feet high. It affords excellent accommodations for vehicles, machines and hand implements, and a store room for seeds and fertilizers.

The plant house recently erected by the Department near the College is sixty feet long and thirty feet wide, and with an extensive range of cold frames and hot beds, is under the supervision of Mr. Boehmer. The students can here be instructed in the important arts of propagating plants from seeds and cuttings, and of their cultivation under glass.

MANAGEMENT OF THE COLLEGE FARM.

Your Excellency has directed me to manage the affairs of the farm according to my best judgment in order to make it a good model for the imitation of Hokkaido farmers, and to render it as useful as possible to the Department in its efforts to establish in this new country a prosperous and profitable agriculture.

Already under the care of Mr. Dun the Department has begun the breeding of horses, neat cattle, sheep

and swine, and the number of those imported has been considerably increased. The want of suitable barns and of cultivated grasses has been the greatest obstacle in the way of obtaining entirely satisfactory results. Many good animals have been raised, but the cost has been unnecessarily great and no adequate provision has been made for their distribution or economical maintenance. The introduction of foreign grasses both for hay and pasturage should be pushed forward as rapidly as possible, and for the present it will be wise economy to import a considerable quantity of seed every year from America, instead of attempting to raise it here. In this way a large extent of good turf and an abundance of excellent hay may be secured, both of which desirable results will be interfered with if the grass be allowed to ripen seed. Moreover, it is very important to naturalize immediately a great variety of forage plants, and the seeds of many grasses, especially, can be profitably grown and prepared for use only by a considerable expenditure of labor and skill.

In the selection of breeds of horses and neat cattle for Yesso it is proper to consider the condition of the country and the character and intelligence of the people. Neither Thoroughbred horses nor Shorthorn cattle can be preserved in their excellence, if bred at all, by ignorant and half-civilized farmers, nor are they so well adapted for their purposes as many other breeds. Large numbers of cheap and hardy cattle from California should be introduced as rapidly as arrangements can be perfected for their care, and the farmers should be induced in some way to breed and use them for labor, or for dairy products.

In regard to the cattle for breeding on the College

farm, I recommend the importation of a few Ayrshires, which are undoubtedly the best breed for the production of milk, butter and cheese. The bulls would be much better adapted in size and inherited dairy qualities than the Shorthorns for crossing with native, or other, cows. It is time that people in Sapporo should cease to consume condensed milk from America, and butter from Denmark, and begin to enjoy the fresh products of Hokkaido farms.

The working bulls now imported from Nambu are very serviceable animals, and it would be an excellent policy to purchase a large number of bull calves, and after their arrival here to castrate them and raise them for working oxen. They will thus be increased in size and docility, and consequent value both for labor and for beef.

For the improvement of the horses of Hokkaido it is first necessary to carry out with vigor the regulations in regard to the castration of native stallions. In their stead horses from Nambu, if well selected, will serve to enlarge the breed and otherwise increase its capacity for usefulness. It is, however, absolutely indispensable to provide the young stock with food and shelter in winter in order to secure any permanent improvement. In the present condition of the Japanese people, if practicable in the existing state of agriculture in Yesso, the breeding of large horses is not likely to be profitable on acconnt of the limited demand. Oxen can be employed for farm work with much greater economy than horses in a new country. Yokes and carts are much cheaper than harnesses and wagons, and the slow, but heavy, ox is much better suited to breaking up new land, and clearing it of stumps, and for hauling lumber and stone than

the lighter and quicker horse. In addition to this the ox if properly fed is always worth his full value for beef, and while the horse is worthless when young, or lame, the well conditioned steer or ox will always bring a good price.

If, however, horses are to be bred for exportation or for draft, I should recommend the importation of large mares from California, with a few good stallions, in order to secure sufficient size and weight for heavy work. For the breeding of riding horses only, the mares of Yesso may be crossed with compact Thoroughbred stallions with the certainty of good results, provided the colts are properly treated.

As soon as fine, sweet grasses can be grown for pasturage and hay, sheep may be profitably bred in great numbers even by the Department. It would also seem to be an easy matter to induce the farmers to keep two or three sheep at least, and thus learn what quick and liberal returns they make. In the selection of breeds, I would be governed chiefly in the outset by the cost, deeming it most important to obtain as many and as cheap as possible, though I should greatly prefer the Californian to the Chinese sheep, as being more hardy and yielding a better fleece. The new sheep barn at Sapporo, with the surrounding pastures, is admirably adapted for its uses, and I would advise that only thoroughbred animals be kept there. These way well be of fine-wooled Merinos, medium-wooled Southdowns and long-wooled Cotswolds or Leicesters. With these, trials can be instituted to learn which will prove most profitable in Yesso, and from them breeding animals may be sent to other parts of the island for the improvement of ordinary flocks.

In regard to swine, the most important thing to be done is to persuade the farmers that it will pay to keep them. For this purpose it seems desirable to send some intelligent person into the different villages to explain the advantages to be derived from the various domestic animals, and to distribute breeding stock upon favorable terms among the farmers. It would also be very useful in promoting agricultural improvement to furnish men with teams to break up new land upon very reasonable terms, and to haul stone and lumber upon wagons or sleds cheaper than it can be transported by pack horses or by man power. The Department should also provide grass and clover seed at the lowest possible rates, and even sell it on credit to all who can be depended on to properly sow it.

Two things essential to a prosperous agriculture are convenient transportation and a ready market, where farm produce can be always sold for cash. These are not often enjoyed in a new country, and Hokkaido is no exception to the general rule. The feeding of silkworms, upon either the Chinese white, or the wild black, mulberry, seems at present to offer an opportunity to raise a crop which may be quickly converted into money at remunerative prices. The extraordinary demand for eggs and raw silk the past year has given a new impulse to this industry which it is to be hoped will advance it permanently. The extensive buildings already completed or in process of erection for the feeding of worms in different parts of Yesso attest the intelligent interest of the Department in this matter. If the Chinese mulberry should prove sufficiently hardy to be grown as a tree in Yesso without winter killing, there would seem to be no obstacle to

success. If on the other hand its long pithy shoots should be badly injured by severe freezing, it is quite possible to cultivate it as a shrub, pruning it nearly to the ground every year. The deep snows of Sapporo would afford the plants thus treated ample protection, just as the tea shrub is preserved in the interior of Nippon.

While the details of the management of the College farm must vary with circumstances, yet there should always be some rational system in view. The following facts and principles seem worthy of consideration in this connection. As the farm is designed to be a model for the imitation of the farmers of Hokkaido, it should first of all be managed with economy. Unnecessary and unremunerative expenditures should be avoided, and in general only those enterprises should be undertaken which promise a speedy return. It is much easier to begin new and apparently promising undertakings than to carry them through to a productive result.

The first improvement to be attempted is the cultivation of foreign grasses and clovers for hay and pasturage. With this object in view twelve hundred pounds of seed have been ordered from America, which has just arrived. The species selected are red and white clovers, timothy, orchard grass, fowl-meadow, red-top, tall fescue, blue grass, meadow foxtail, sweet-scented vernal grass, sheep's fescue, red fescue, water sweet grass, rough-stalked meadow grass, woolly soft grass, rye grass and oat grass. It is proposed to sow these on the smooth and mellow land which has been under the plow for the last two or three years. They will be variously mixed and the several mixtures sown in such a way as to determine,

if possible, the best time and manner of seeding down grass land, and the kinds best suited for permanent mowing and for pasturing. A large part of the seed will be sown early this spring, the land which is already plowed receiving a top-dressing of either fish pomace or unleached wood ashes. Some will be tried alone, while with other portions oats or millet will be sown and cut for hay before they blossom, that they may not weaken the young grass. Experiments will also be made in August, according to the most approved method of laying down land in Massachusetts.

BEET SUGAR.

Among the agricultural industries of the world which might be successfully undertaken in Hokkaido there is none that seems to me so worthy the attention of Your Excellency as the production of sugar from the sugar-beet. This business originated in France, and was first rendered profitable under the wise policy of Napoleon the Great. Yet its progress was slow till about 1850, since which time its growth has been unprecedented. The production of beet sugar in France in 1850 was 60,000 tons and in 1870 it was 300,000 tons. In Austria the increase for the same period was from 10,000 tons to 80,000 tons; and in Russia, from nothing in 1850 to 100,000 tons in 1870. The people of Russia now consume three times as much sugar as they did before the introduction of this industry into their country. The tax on raw sugar in France in 1870 was three and three quarters cents per pound, which would afford a revenue on 300,000 tons of 22,500,000 dollars. A portion of this

tax is remitted in the case of sugar exported to other countries. The government income from duty on alcohol, distilled from the molasses of the beet sugar factories, amounted the same year to more than 3,000,000 dollars. The tax in Prussia was three and two sevenths cents per pound, and the revenue not less than 15,000,000 dollars. From these statistics it appears that it must be a very profitable crop, since the tax equals nearly half the value of the sugar and amounts to from forty to seventy dollars an acre on the land cultivated in beets.

The quantity of sugar consumed annually is not less than 3,000,000 tons, of which the United States uses more than any other country, or about 700,000 tons, while Great Britain imports more than 600,000 tons. The annual product of beet sugar is about 700,000 tons and is constantly increasing. Sugar is a delicious and healthful article of food, and the demand for it steadily advances with the progress of civilization. As it is so universally and extensively used, the market is never glutted, and the price is very uniform. The value of refined beet sugar is from 200 to 300 dollars per ton, and, therefore, it may be cheaply transported to a market in any part of the world. The peculiar adaptation of this industry to the present wants and condition of Hokkaido will appear from the following considerations.

First.—The soil in the valley of the Ishcari is well suited to the growth of a sweet and excellent beet, free from an excess of nitrogenous compounds, which greatly interfere with the profitable extraction of the sugar. It contains an abundance of organic matter, and the subsoil is of such a character as to allow deep tillage, and to insure freedom from stagnant

water. The soil is very finely comminuted and perfectly free from stones, and with barely sufficient slope to carry off the surface water.

Secondly.—The climate seems to be admirably adapted to the successful cultivation of the sugar beet. The summer is warm and the rainfall sufficient to cause a steady uniform development of the roots, while the autumn is all that could be desired for ripening the crop. The months of September and October, being bright and beautiful, and free from injurious frosts, insure the prevalence of the best possible weather for the perfection and utilization of the roots. The mildness of the winter temperature and the great depth of snow are also very favourable for the preservation of the beets for winter use in the best condition at small expense.

Thirdly.—The cheapness of labor, its cost being about one half the price in France, and the agricultural habits of the people, offer special advantages to this business. The Japanese farmer cultivates but a small area, and keeps this well tilled and quite free from weeds. He delights especially in a fine crop of big radishes, and understands how to raise roots.

Fourthly.—The low price of fuel renders Sapporo a very favorable place for this industry. Wood of any desired description cut into lengths of two feet may be purchased for one dollar and a half per cord of one hundred and twenty eight cubic feet, and the supply is inexhaustible. Most excellent bituminous coal is also to be found in abundance at less than thirty miles from the city.

Sixthly.—The sugar manufacture requires an abundance of running water of good quality, which the clear and unfailing streams from the mountains here

can furnish, together with excellent water power, which may be made very useful.

Seventhly.—Lime, which is indispensable in the defecation of the juice, may be easily obtained from Hakodate or the Cliffs of the Ishcari.

Eighthly.—The want of domestic animals for the production of meat, hides, wool, dairy products and fats for exportation, prevents the farmers of Yesso from obtaining the profitable returns of stock farming and necessitates the adoption of some other branch of agricultural industry in order to secure anything like reasonable progress in the colonization of the island. Beets for sugar are the only crop which can be raised for any considerable period in large quantity without the application to the soil of the manure of animals, or of costly commercial fertilizers. Under present circumstances, the large amount of refuse material, such as leaves, trimmings of roots, waste pulp and scum, amounting in all to eight or ten tons per acre, could probably be returned directly to the soil with the greatest profit, as is practiced even now in Belgium. But a large additional income is usually derived from feeding this refuse to animals, which thrive exceedingly well upon this food alone, and in France are often fattened for slaughter without the addition of anything else. It is a remarkable fact that those districts in France which produce the most sugar also produce a larger amount of bread and meat than they did before the establishment of this industry. They are in every respect more prosperous and the wages of laborers are higher, while work is more abundant than in other parts of the country. It is a matter of great importance to provide labor for men, women and children in winter as well as in summer, and this

is done in the sugar factories, which make sugar only during the fall and winter. Thus the same hands employed to raise the beets in summer aid in their manufacture in winter.

Ninethly.—The beet sugar business has ceased to be an experiment and attained a marvellous development, and in every country where it has been introduced it has been successful and has steadily increased in importance. There is, therefore, no possible risk under proper management and favorable conditions in undertaking it. Next to the fisheries, which ought to yield a very large revenue with a comparatively small expenditure, the sugar production may certainly be rendered the most profitable business in Hokkaido.

Tenthly.—Sapporo is the best location for the inauguration of the enterprise on account of its excellent soil, its large population, its abundant and cheap fuel and its clear mountain streams. The scientific men, the valuable library, the convenient chemical laboratory and the fertile experimental and model farm of the Agricultural College, will all be most important aids in the accomplishment of this great work.

The only practical difficulty to be encountered is found in the fact that the extraction and refining of the sugar can only be carried on advantageously on a large scale. The amount of beets for daily consumption in a suitable factory is from fifty to sixty tons, or the product of about three acres of land, which will yield from seven to ten thousand pounds of refined sugar every twenty-four hours. The machinery and buildings for such an establishment would cost not less than fifty thousand dollars, and the business would

require the use of a considerable sum in addition for the active capital to be employed in defraying current expenses, such as the wages of employès and the purchase of roots. There are two factories in Germany each of which has a capital of more than a million of dollars, and gives employment to more than three thousand persons. In France, coal costs five dollars a ton, labor forty cents a day, beets about four dollars a ton, land fifteen dollars a year per acre, and the sugar is taxed three and three-fourths cents a pound, and still the beet sugar industry is more certain and remunerative than almost any other. Will it not pay in Hokkaido?

As there are several methods of treating the beet root, and as the prices of machinery are more or less fluctuating, I would recommend that a careful inquiry be instituted in reference to the whole matter, and an elaborate report be prepared with detailed plans for everything required before any further expenditure be authorized.

Meanwhile, beet seed of the best sorts has been procured and careful experiments will be made by Professors Brooks and Penhallow in regard to the quantity and quality of the roots produced on the college farm during the ensuing season. If the subject should receive immediate attention, it would be possible to get a factory into complete running order in September, 1878.

CONCLUSION.

In the autumn of 1875 Your Excellency approved a plan for the Sapporo Agricultural College, presented for your consideration by Hon. Dzushio Hirotake, the present Director, and you requested His Excellency

Yoshida Kiyonari, the Japanese minister at Washington, to select a president and two professors for the same. As the Massachusetts Agricultural College at Amherst was chosen as the model for the new institution, so the faculty of the latter were sought from among those who were, or had been, connected with the former. The trustees of the Massachusetts College kindly loaned their president for a year that he might organize the Japanese College, and he naturally took as his companions and assistants two graduates of the institution under his charge. These three gentlemen started for Sapporo on the twentieth of May, 1876, and arrived in good condition on the thirty-first of July following.

The exercises at the opening of the College, on the fourteenth day of August, consisted of addresses in Japanese from Your Excellency, from His Honor Vice-Governor Hori and Director Dzushio, and on behalf of the students, from Mr. Yasuda. The President then spoke briefly in English, and a pleasant collation finished the ceremony in a suitable and satisfactory manner.

From that time to the present the affairs of the College have given no trouble to any one. The officers have been very busily engaged in their several tasks, and the students have been perfectly obedient and faithful, and as successful as their ability would allow. Every officer and every student has promised not to indulge in the use of alcoholic drinks, opium or tobacco, and neither to gamble, nor be guilty of profane swearing while connected with the College. There need, therefore, be no anxiety about the conduct of the first class, and it is expected that their excellent example will be imitated by their successors.

Besides the conscientious performance of their required duties, the students have become greatly interested in out-door exercises and expecially in the collection of specimens in botany, zoology and entomology. Already a foundation is laid for a museum of natural history which will undoubtedly be gathered very rapidly. The long summer vacation should be devoted by the professors and students to scientific excursions into the unexplored portions of the island, and as soon as possible a complete collection of all the soils and minerals, the herbaceous and woody plants, including every variety of timber, and all the forms of animal life, should be brought together and preserved in a suitable building.

Living specimens of plants for the botanic garden should also be procured from every available source both of Hokkaido, and of other portions of the Empire. Contributions may also be readily obtained from other countries by exchange. Prof. C. S. Sargent, of Boston, director of the Arnold Arboretum, in acknowledging the receipt of seeds sent to him last autumn writes as follows—"Now what can I do for you? I should like to do something, and will send you all the American seeds you want, and any quantity of seedling plants of our trees and shrubs."

A literary society has been organized with the name Kaishikisha, and all the members of the College are striving at their weekly meetings to improve in debating, writing and speaking, in both the Japanese and English languages.

A catalogue of the books in the library is appended to this Report, and it is hoped that an important addition to the English portion will be made this year. A large number of new literary and scientific works

are almost indispensable for the use of both professors and students. Books are their implements, without which they can do but little.

It is very desirable that a building be provided for a gymnasium and military drill hall and armory. In order to develop properly their bodily powers and render the young cadets active, graceful and vigorous, they should be carefully instructed in the laws of health, and thoroughly trained in gymnastic exercises. These will be most useful if they can be practised in winter and in rainy weather, when it is difficult to accomplish much out of doors.

Although the students are destined to become officers, it is intended to teach them thoroughly all the processes of practical agriculture, including the use of hand implements and of machinery, the care of domestic animals, and the management of teams both of oxen and horses. They will work in the field with Professor Brooks two afternoons of each week, when the weather permits.

In addition to their regular prescribed duties in the recitation rooms the officers of the College have very cheerfully done whatever they could to advance the interests of the Department. Professor Penhallow has spent much time in the tannery, assisting in perfecting the process for converting deerskins into glove and chamois leather, and with good results. He has also prepared plans for a new tannery, and assisted in properly locating it. The drawings and specifications for the new chemical laboratory and its fixtures have also been furnished by him, as well as the sketches of the elevation and interior of the model barn for this Report. Besides this he has zealously collected specimens of silk, wool, flax, hemp and other

fibres and subjected them to a thorough study with his powerful microscope. Upon the structure of these he has written for this Report an introductory essay, which will be followed by other articles as circumstances may permit in years to come.

Professor Wheeler has performed a large amount of valuable work as an engineer under very difficult circumstances on account of the season. In December he surveyed the routes for the enlargement and straightening of the canal from Sapporo to Shinoro. He spent most of the winter vacation, in January, in locating a new highway between Sapporo and Otarunai, and he also located a railroad between the same points. For all the above-named improvements he furnished detailed estimates of the cost of construction and elaborate reports with maps ; and also instituted a comparison of these routes with the proposed railroad to Mororan. His general views on the various plans suggested are appended to this Report. He also surveyed and prepared a map of the College farm and determined the levels required for the locations of drains.

He furnished the plans and specifications for the model barn, for a soldier-farmer's house and for a weather station. He also held numerous consultations with officers of the Department and made drawings for the construction of a machine for testing the strength of materials, a sled, a pump and a snow-plow. Experiments were also instituted by him to determine the value of various clays for brick-making. But perhaps nothing he has done is more important than the establishment of a weather station with a full set of instruments, and the careful observation of meteorological phenomena, which he has undertaken.

His report upon the subject appended to this, will be found to contain much valuable information in regard to the method of taking such observations, and their importance to the country. His recommendation that another station be established on the north-east coast is worthy the attention of Your Excellency.

Besides the management and control of the College and English School, the President has given two hours of instruction daily, chiefly in agriculture, structural, physiological and descriptive botany, human anatomy and physiology, and the laws of health and morality. He has also been constantly occupied in directing the improvements carried on at the college farm, including the details of construction on the model barn, and has conferred repeatedly with officers from Nanaye in regard to the planting of forest trees and general farm management. He has also made excursions for the examination of coal beds, fisheries, stone quarries, coniferous forests for the manufacture of tar and turpentine, maples for the production of maple sugar, and wild mulberry groves with reference to the best mode of pruning and treating them for the feeding of silk-worms. The general subject of planting, preserving and utilizing forest trees in Hokkaido is now under his consideration with a view to the preparation and enforcement of a suitable code of laws relating to forestry.

The foregoing details in regard to the work accomplished by the officers of the College during the seven months of their residence in Sapporo will show Your Excellency that they have not failed to take a lively interest both in their proper educational duties, and in every matter pertaining to the development of the vast and naturally wealthy province under your government.

In August last the College was visited by His Excellency Prime Minister Sanjo, Minister of Foreign Affairs Terashima, Minister of War Yamakata, Minister of Public Works Ito and many other officers of their party. The Prime Minister was graciously pleased to express in writing his satisfaction with what he saw, and generously presented a testimonial of his approval to each of the best five scholars.

With sincere thanks for the exceeding courtesy with which I have been treated on all occasions, and especially for the unusual confidence reposed in me, as shown by the promptness with which my suggestions have been followed, and the independent authority with which I have been clothed, I remain,

With hearty respect,

Your Excellency's

Most obedient servant,

W. S. CLARK,

President of Sapporo Agricultural College and Director of College Farm.

Sapporo, Hokkaido,

March 2nd, 1877.

SAPPORO

AGRICULTURAL COLLEGE,

1876-7.

CATALOGUE

OF

OFFICERS AND STUDENTS.

GONDAISHIOKIKUWAN DZUSHIO HIROTAKE,
Japanese Director.
WILLIAM S. CLARK, PH. D., LL.D.,
President and Director of College Farm.
WILLIAM WHEELER, B.S.,
Professor of Mathematics and Civil Engineering.
DAVID P. PENHALLOW, B.S.,
Professor of Botany and Chemistry.
WILLIAM P. BROOKS, B.S.,
Professor of Agriculture.
HORI SEITARO,
Secretary and Interpreter.
YOSHIDA KIYONORI,
Farm Overseer.

FRESHMAN CLASS.

Arakawa Shigehide	Tôkiô.
Fujita Yoshihide	Shiga.
Hiyoto Torao	Sendai
Ideta Seitaro	Oita.
Ito Hadzutaka	Tôkiô.
Kaminura Yukitaka	Kagoshima.
Kuroiwa Yomonoshin	Kochi.
Naito Yoshikane	Tôkiô.
Nakashima Shinshi	Kanazawa.
Ono Kanemoto	Imaizumi.
Ono Takuma	Tobetsu.
Oshima Masatake	Atsumi.
Sato Isami	Yoichi.
Sato Shosuki	Hanamaki.
Shimadzu Isaharu	Shidzuoka.
Takabayashi Kichitaro	Shidzuoka.
Tamaki Kiyosaburo	Tôkiô.
Tanouchi Steroku	Kochi.
Uchida Kiyoshi	Kochi.
Watase Torajiro	Tôkiô.
Yamada Yoshihiro	Tôkiô.
Yanagimoto Michiyoshi	Kuwana.
Yasuda Nagaaki	Mitajiri.
Yokoyama Hikojiro	Tôkiô.

OBJECT AND PLAN OF ORGANIZATION.

The Sapporo Agricultural College was founded by the Colonial Department for the education and practical training of young men from all parts of the Empire who are expected to become its employès after graduation, and to remain in its service for the term of five years. The number of students is limited to fifty, and all their expenses while in College are defrayed by the Government.

The course of instruction will occupy four years, and those who complete it in a satisfactory manner will receive the degree of Bachelor of Science.

The following branches of knowledge will be regarded as important parts of the curriculum, namely, the Japanese and English Languages; Elocution, Debate, Composition and Drawing; Book-keeping and the Forms of Business; Algebra, Geometry, Trigonometry, Surveying, Civil Engineering, so far as required in the construction of ordinary roads and railroads, and of works for drainage and irrigation; Physics, with particular attention to Mechanics; Astronomy; Chemistry, with especial regard to Agriculture and Metallurgy; Structural, Physiological and Systematic Botany; Zoology; Human and Comparative Anatomy and Physiology; Geology; Political Economy; Mental and Moral Science; Physical Culture; Military Science and Tactics; and the most thorough instruction in the theory and practice of Agriculture and Horticulture, the various topics being discussed with constant reference to the circumstances and necessities of the farmers of Hokkaido.

CALENDAR.

Each collegiate year will begin on the fourth Thursday of August, and close on the first Wednesday of July. It will be divided into two terms, the first continuing from the fourth Thursday of August to the fourth Wednesday of December inclusive, and the second, from the fourth Thursday of January to the first Wednesday of July.

TERMS OF ADMISSION.

Candidates for admission to the Freshman Class will be examined orally and in writing upon the following subjects, namely; The Japanese and English Languages, which they should be able to read, write and speak with correctness and facility; Arithmetic, Geography and Universal History, the knowledge required being equivalent to that contained in the common higher text-books for public schools.

Candidates for examination must be at least sixteen years of age, of sound constitution and good character. They must also sign the prescribed form of contract, with the Government, and furnish a satisfactory surety, residing either in Tôkiô or Hokkaido.

RANK AND DISMISSION.

An accurate record will be permanently kept of the deportment, attendance and scholarship of every student. At the end of each term an examination in writing will be held and the papers marked upon the scale of one hundred for perfection. The average mark for the daily recitations of the term will be added to the examination mark and the sum divided by two,

The quotient thus obtained will be the mark for the term in the subject under consideration. The sum of the marks in the several departments of instruction, divided by the number of such departments in which the student has been taught during the term, will give his general average mark, and by this his rank in the class will be determined. When, however, the total number of exercises in the departments for a term differs materially, the general average mark shall be obtained by the following rule, namely ; multiply the number of exercises in each department by the average mark of that department, and divide the sum of the products thus resulting by the total number of exercises in all departments for the term. The quotient will be the general average mark.

Only such students will be allowed to go on with their respective classes as have made satisfactory progress in the studies of the preceding term, and have been regular in attendance and exemplary in conduct.

Any student who may be dismissed from College on account of deficient scholarship, or misconduct, or who may leave voluntarily before the expiration of the time stipulated in his contract, will be required to pay the cost of his education as specified in said contract up to the date of his leaving. But no payment will be expected in the case of any one who may die, or who may be discharged on account of ill health, or by the Government without fault on his part.

Any student, desiring temporary leave of absence on account of the sickness or death of a relative, is required to present an application from his parent or guardian accompanied by a certificate from a physician and the chief magistrate of the town where the said relative resides.

GENERAL RULES.

1.—Regular College exercises will be held every forenoon, except on Sundays and holidays, in term time. Wednesday afternoons will be regarded as time for recreation. Other afternoons will be occupied by field work, military drill, scientific excursions, or as may be ordered by the President with the approval of the Director.

2.—Students must be regular in attendance upon all prescribed duties, and if necessarily absent from any, must as soon thereafter as practicable render an excuse in writing to each officer from whose exercise they have been absent.

They must be quiet and orderly in and around the College buildings, and behave everywhere with propriety.

3.—All the cases of discipline, except such as relate to minor offences subject directly to the control of individual officers, shall be acted upon by the College Faculty, and their decision shall be approved by the Director before the infliction of punishment.

4.—The College Faculty shall meet for business at the call of the President, or shall hold stated sessions as they may deem necessary. They shall elect a Secretary who shall keep a record of all their votes in a suitable book, and also a register of all the marks of every student as reported at the end of each term.

5.—The President shall exercise a general supervision over all the affairs of the College; shall see that the duties of Professors, students and employés are properly assigned and performed; and, while consult-

ing freely with the Faculty on questions of discipline and administration, shall have authority to veto their votes and act according to his own judgment whenever he may deem it necessary for the best interests of the institution.

He shall prepare for publication an annual report upon the work of the College during the preceding academic year, and state the condition and progress of the several Departments. The report shall also be accompanied by such useful papers as may be prepared by members of the Faculty relating to observations, experiments and investigations in agriculture or any branch of natural science.

6.—The members of the Faculty of instruction and government shall each be responsible for the proper education and discipline of the classes under his charge, and shall perform such official duties as may be assigned him by the President. He shall also be responsible for the safe-keeping of the books, apparatus and specimens in his department, and for the economical use of all material furnished for experimental or practical purposes. All requests for supplies, repairs and improvements shall be made to the President.

COURSE OF STUDY AND INSTRUCTION.

FRESHMAN YEAR.

First Term.—Algebra, including Logarithms, 6 hours each week; Chemical Physics and Inorganic Chemistry, 6 hours; English, 6 hours; Japanese, 4 hours; Military Drill, 2 hours; Manual Labor, 6 hours.

Second Term.— Geometry and Conic Sections, 6 hours each week; Organic and Practical Chemistry, 8 hours; Agriculture, 4 hours; English, 2 hours; Elocution, 2 hours; Freehand and Geometrical Drawing, 3 hours; Military Drill, 2 hours; Manual Labor, 6 hours.

SOPHOMORE YEAR.

First Term.—Agricultural and Analytical Chemistry, 8 hours each week; Botany, 3 hours; Human Anatomy and Physiology, 3 hours; English, 2 hours; Elocution, 2 hours; Agriculture, 4 hours; Military Drill, 2 hours; Manual Labor, 6 hours.

Second Term.—Trigonometry and Surveying, 6 hours each week; Quantitative Analytical Chemistry, 8 hours; Botany, 4 hours; Agriculture, 2 hours; English and Japanese Translations, 2 hours; Mathematical Drawing and Plotting, 3 hours; Military Drill, 2 hours; Manual Labor, 3 hours.

JUNIOR YEAR.

First Term.—Mechanics, 6 hours each week; Zoology, 3 hours; Botany, 3 hours; Fruit Culture, 3 hours; English, 4 hours; Japanese, 2 hours; Military Drill, 2 hours; Manual Labor as required.

Second Term.—Astronomy and Topography, 6 hours each week; Stock and Dairy Farming, 3 hours; History of English Literature, 6 hours; Landscape Gardening, 3 hours; English and Japanese Compositions and Translations, 2 hours; Military Drill, 2 hours; Mechanical and Topographical Drawing, 3 hours.

SENIOR YEAR.

First Term.—Physics, 6 hours each week ; Veterinary Science and Practice, 6 hours each week ; Geology, 4 hours ; Book-keeping, 4 hours ; Extempore Debate, 2 hours ; Microscopy, 3 hours ; Military Drill, 2 hours.

Second Term.—Roads, Railroads and Hydraulic Engineering, 6 hours each week ; Mental Science, 4 hours ; Political Economy, 4 hours ; Original Declamations, 1 hour ; Military Drill, 2 hours.

REMARKS.

The foregoing programme of exercises is intended to be followed as nearly as the circumstances of the College will allow. In cases of necessity studies may be transposed from one term to another. The manner in which the several branches shall be taught must depend largely upon the ability and preference of the instructor. Oral and practical teaching are most desirable, though text-books may often be wisely employed in connection with them. The student should be constantly required to take notes of all information imparted which is not contained in the text-book, and should carefully and neatly copy them into a suitable book. The note books of the students should be critically examined and corrected by the teacher in all cases.

The hours of recitation and lectures should usually be in the forenoon, beginning at half past eight o'clock. Drawing will come in the afternoon and each exercise should continue one hour and a half. Military Drill should occupy one hour of the afternoon, and Manual

Labor three hours upon the days appointed for them. If the weather is unfavorable, they should be omitted.

It matters little what text-books are adopted, provided the teachers are competent, and suitable books of reference are accessible to the students.

In the study of the English and Japanese Languages great pains should be taken to secure fluency and correctness both in speaking and writing, and especially in oral and written translations from one to the other.

In Botany, Zoology and Geology the student should be required to observe closely, and to collect and preserve specimens of all sorts.

The instruction should be as practical as possible in all departments so that the graduates of the College may ever be distinguished for their sound judgment, their enterprising spirit, and their strict morality. Every teacher should make his character and conduct worthy the imitation of his pupils, and should seize every proper opportunity to impart to them useful information in regard to the care and control of their bodies, the discipline and enrichment of their minds, and the dignity and worth of their immortal natures.

PRIZES.

For the purpose of rewarding good conduct and earnest and faithful scholarship, the Faculty are authorized to divide among the members of the College the sum of one hundred and fifty dollars at the close of each collegiate year. The awards will be in sums of money not exceeding twenty dollars to any one student, and will be so distributed by vote of the Faculty as to recognize and encourage improvement and excellence in all departments.

Form of Application for Admission.

Form of Application for Admission to Sapporo Agricultural College to be addressed to the Chief of the Colonial Department at Tôkiô or to the Director of the College at Sapporo :—

I respectfully ask to be received as a government cadet in the Sapporo Agricultural College, provided I am able to pass a satisfactory examination.

Signature.....

Date..... and Residence.....

Agreement of Successful Applicant.

Having been admitted as a cadet to the Sapporo Agricultural College, I promise and agree as follows, namely :—

1.—If I should be expelled from the College on account of any violation of the laws of the country or of the Institution, or if I should be dismissed on account of deficient scholarship, I will pay immediately to the treasurer thereof the cost of my education from the date of my admission to the time of my expulsion or dismissal at the rate of eleven *yen* per month.

2.—After graduation I will become a citizen of Hokkaido, and will serve in the Colonial Department for five years upon the same terms as other officers of similar rank. I also promise never to petition for a change of my citizenship.

3.—I will not offer my resignation as a cadet or an officer during the period specified in this agreement, even though sickness or other serious hinderance to my continuance should arise. If I should be compelled by unavoidable circumstances to ask for my

discharge, I promise to pay to the treasurer my proportion of the whole expense of maintaining the College during my connection with it, the total amount being divided by the number present with me.

Signature.....
Province.....
Class.....
Date..... Father.....

Agreement of Surety.

As surety for cadet————if admitted to the Sapporo Agriculture College, I hereby promise and agree to become responsible for his faithful fulfilment of his agreement with the Colonial Department, and to pay promptly all his indebtedness to the treasurer of the College in case of his failure so to do.

Signature.....
Date..... Province .....

Endorsement of Provincial Governor.

The accompanying documents are correct, and the within named————————may be admitted to the College.

Signature.....
and Seal.....
of Governor.....
of Province.....

Private Cadets.

Private cadets may be received on application to the Director of the College at Sapporo. They will be required to pay ten *yen* per month, and to furnish a surety like Government cadets. They will be treated in all respects like other cadets ; but will not be compelled to remain in the employ of the Colonial Department, or to become citizens of Hokkaido.

CATALOGUE

OF

OFFICERS AND STUDENTS

OF

PREPARATORY DEPARTMENT.

WILLIAM S. CLARK, PH. D., LL.D.,
President.

IKAWA KIYOSHI,
Instructor in English Language.

YAMADA MASAKUNI,
Instructor in Mathematics.

NAGAO FUSAN,
Instructor in Chinese and Japanese Languages.

MORI GENZO,
Business Manager.

STUDENTS.

Hino Atszane	Sapporo.
Hori Soichi	„
Ishikawa Kinjiro	„
Kanno Shiu	„
Kojima Kisaku	„
Kon Gaisaburo	„
Koseki Yoshinobu	„
Miki Uchio	„

Nakagana Minosuki..... „
Nakane Akira..... „
Nakane Kotobuki..... „
Nakano Hidejiro..... „
Oinowye Arao..... „
Ooka Chiyokichi..... „
Oota Chiyozo..... „
Sase Tatsaburo..... „
Senokuchi Takakane..... „
Takabatake Giichi..... „
Takabayashi Kinzo..... „
Ujiye Kichigoro..... „
Unayama Hachiya..... „
Yanase Makoto..... „
Yoshimoto Kikujiro..... „
Yuki Shiyogo..... „
Yuyama Tomonori..... „
Yuyama Tomoyuki..... „

PREPARATORY DEPARTMENT.

This Department is designed to prepare students for admission to the Sapporo Agricultural College, whose President will superintend the instruction of its classes. The students will be furnished with books and stationery and receive their education without charge, but will not be provided with board and clothing. The calendar will be the same as that of the College. Applicants for admission should be not less than twelve years of age, and well taught in the elements of the Japanese language.

COURSE OF INSTRUCTION.

FIRST YEAR: THIRD CLASS.

First Term.—English Language, 6 hours each week; names of common things; simple sentences, and familiar colloquial phrases; correct and distinct pronunciation of elementary sounds. Reading, Spelling and Defining, 6 hours; Mental Arithmetic, without text book, 6 hours; every student to have a slate or paper and pencil. Writing, 6 hours. Special attention to be given to the proper mode of holding the pen, the position of the body, and neatness of the book.

Second Term.—English Language, 6 hours each week. Learning of words and construction of sentences. Distinct utterance and correct pronunciation. Reading, Spelling and Definitions, 6 hours; Arithmetic, 6 hours. Mental practice and exercise on the black board and paper. Writing, 6 hours.

SECOND YEAR: SECOND CLASS.

First Term.—English Language, 6 hours each week. Exercises in Conversation and Recitation. Familiar talks about common things and their repetition by the pupils. Reading, Spelling, Defining and Dictation, 6 hours. Written exercises, carefully corrected by the teacher. English Grammar, without a text-book, 3 hours. Practice in correcting errors of language. Geography, 6 hours. Oral instruction with globe and wall maps, and afterward a text-book. Writing Japanese, 3 hours.

Second Term.—English Language, 6 hours each week. Oral lessons, with examinations on them. Composition on topics discussed, sometimes written in the recitation room and sometimes more carefully prepared. Reading and Spelling and Analysis of sentences with oral instruction on the modifications of parts of speech, 6 hours. Practical Arithmetic, 6 hours; Geography, 3 hours. Japanese History, 3 hours.

THIRD YEAR: FIRST CLASS.

First Term.—English Reading and Spelling, 6 hours each week. The text-book in History may be used.

English Grammar, 6 hours.

Universal History, 6 hours.

Geography, 3 hours.

Writing, 3 hours. Practice in Letter-writing.

Second Term.—

English Grammar, 3 hours each week.

Arithmetic, 6 hours.

Geography 6 hours.

History, 6 hours.

English and Japanese Writing, 3 hours each.

CATALOGUE

OF

BOOKS IN THE ENGLISH LANGUAGE.

Abel, C. D. .....Machinery with Atlas, vols. 1-2.
Abert, S. T. .....Is a Ship Canal Practicable?
Adams, A. .....Manual of Natural History.
Agricultural Department, U.S. .....Monthly Reports of 1867, '68, '69, vols. 1-3.
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Allen, & Co., Pub....Catalogue of Farm Machinery.
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American Bible Society, Pub. .....English Bible, 3 copies.
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OF

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From September 1, 1876 to April 1, 1877,

MADE AT SAPPORO, JAPAN,

BY

WM. WHEELER,

Professor of Mathematics and Civil Engineering,

Sapporo Agricultural College.

Latitude, 43° 3′ 56″ N. Longitude, 141° 22′ 49″ E.

Tidal Elevation, 75 feet.

METEOROLOGICAL REPORT.

The work of the Meteorological Station was organized under my department September 1st, 1876, at which time the accompanying register was initiated.

Observations are taken three times daily, at 7 A.M., 2 P.M., and 9 P.M., in accordance, mainly, with the standard system of the Smithsonian Institution, Washington, U. S. The following data are thereby determined :—

1. *Temperature in the open air.*—Stated in degrees according to the scale of Fahrenheit's thermometer. The maximum and minimum temperatures for each day are also determined by self-recording thermometers.

2. *Pressure of the atmosphere.*—Determined by a mercurial barometer. The hight of the mercury column is stated in inches, and is reduced to that which would occur if the mercury was at 32 degrees, Fahrenheit.

3. *Pressure of aqueous vapor.*—Obtained from readings of the wet and dry bulb hygrometer, by means of tables based on experiment. Under this head are entered the numbers which indicate the inches of mercury in a barometer, which the moisture of the atmosphere alone will sustain,—the whole pressure of the atmosphere, as given under the head of

"Barometer," being due, conjointly, to the weight of the air and the moisture which it contains.

4. *Relative humidity of the atmosphere.*—Determined from observations of the wet and dry bulb hygrometer. This is expressed by the per centage which the amount of moisture actually present in the air bears to the amount which the air would contain at saturation.

5. *Time and amount of rain and snow.*—Under this head are entered the time of beginning and ending of the fall of rain or snow, and the amount in inches of rain or melted snow collected in the gauge at the surface of the ground: also the depth of the snow in inches.

6. *Direction of wind.*—Representing the direction from which the wind is blowing as indicated by a vane. The direction is entered in sixteen points of the compass.

7. *Velocity and progress of wind.*—Ascertained by Robinson's anemometer,—showing respectively the rate of movement in miles per hour, and the entire progress of the wind during the intervals between the successive observations.

8. *Amount of cloudiness.*—Determined by estimation, and designated by figures representing the per centage of sky obscured at each hour of observation.

6. *Forms or varieties of cloud.*—These are classified somewhat arbitrarily as follows:—*Cirrus* (cir.), consisting of slender filaments either parallel or divergent, having the greatest altitude, the least apparent density, and the greatest variety of form. The cirri are often composed of snow or ice crystals, and it is among these clouds that halos and parhelia are formed. *Cumulus* (cum.), consisting of large white rounded

masses rising either from an irregular or horizontal base. The cumuli are formed by the condensation of moisture in ascending currents of air; their hight varying greatly, but always less than that of the cirri. *Stratus* (str.), composed of continuous horizontal sheets or layers, formed in the lower atmosphere, usually at about sunset and during the night. *Nimbus* (nimb.), is applied to clouds from which rain or snow is falling. The primary forms of rain-clouds are frequently either cumulus or stratus. Intermediate varieties, or combinations of the foregoing are indicated thus:—*Cirro-cumulus* (cir-cum.); *Cirro-stratus* (cir-str.); *Cumulo-stratus* (cum-str.); and *Cirro-cumulo-stratus* (cir-cum-str.).

Observations of casual phenomena, such as lightning, rainbows, halos, earthquakes, early and late frosts, depth of ground frozen, extraordinary fluctuations at irregular hours, etc., are also recorded.

Appended to each monthly register is a summary, showing the mean, the maximum, and the minimum of the several observations for the entire month, and also for each of the three series of daily observations.* At the close of each year, an annual summary will be prepared, and at all times, it should be the endeavor of the observers to determine as accurately as possible the climatic laws of this locality, and to derive practical lessons therefrom in the interests of agriculture, the constructive arts, commerce, and those mightier factors in the economy of nations,—the health, energy and comfort of the people.

* For want of space, and for the sake of simplicity, several columns of daily "means," the "kind of clouds," and the monthly "mean," "maximum," and "minimum" results for each of the three series of daily observations are omitted in the accompanying abstract of the Meteorological Register. Complete copies are filed at the Capitol, Sapporo, and at the office of the Colonial Department, Tôkiô.

In order to facilitate the work of the observer, and to secure the highest degree of accuracy in the results, a carefully planned meteorological station has been erected in an isolated position, upon the roof of the Kiu Honjin, and fitted out with a set of standard instruments, made by Casella, London.

The value of meteorological records depends upon their accuracy, completeness, and their intelligent interpretation and use. They constitute an element of peculiar importance in the development of a new section of country, especially if its climatic character is unfavorably belied through ignorance existing within its own realm. They furnish to the world another chapter of its natural history, publishing the true story of its climatic capacity,—its flora, its posisible agricultural wealth, the salubrity of its atmosphere, the beauty of its landscape,—in a language which all may comprehend. Connected with a fertile soil, abundant forests of valuable timber, and extensive mineral resources, there could be no better advertisement to invite enterprising settlers and capitalists to Yesso, than the assurance of a climate favorable to the highest excellence of her future agriculture, and promising pleasant, healthful homes to all her people.

The work that has here been entered upon will be an essential element in conducting agricultural experiments under the auspices of the College, and will afford a valuable source of instruction for the students. It will also furnish an important link in the chain of positive evidence by which the meteorological laws prevailing throughout the Empire, and along the eastern coast of Asia may be determined, and their manifestations foretold.

By the adoption of a well organized system of ob-

servations and comparisons of the meteorological phenomena in the United States, the approaching conditions of temperature, atmospheric pressure, rain, snow, wind, cloud, etc., are published daily with almost perfect accuracy, throughout the whole country, by the agency of the telegraph and the press; thus conferring countless benefits upon all classes, and especially upon agricultural and commercial enterprise. To prepare for the introduction of a similar system in Japan, additional stations must be established throughout the country, according to a comprehensive and carefully devised plan.

Having been notified that a duplicate set of meteorological instruments belonging to the Kaitakushi is now in Sapporo, I would respectfully recommend that they be utilized, and that a station for observations be established at some point near the extreme eastern or north-eastern coast.

PLUVIOMETER. AND AMOUNT OF RAIN AND SNOW.				ANEMOSCOPE. DIRECTION OF WIND.		
INNING.	TIME OF ENDING.	AMOUNT OF W'TER	DEPTH OF SNOW.	7 A.M.	2 P.M.	9 P.M.
	—	—	—	S.S.E.	W.N.W.	S.W.
	—	—	—	E.N.E.	N.	S.
	—	—	—	E.S.E.	N.W.	S.S.E.
	—	—	—	S.S.E.	S.S.E.	E.
	—	—	—	S.E.	N.W.	—
	—	—	—	W.S.W.	N.W.	S.
	—	—	—	S.E.	E.S.E.	S.
7 a.m.‡	—	—	—	E.N.E.	S.S.E.	N.
	—	—	—	W.	N.W.	W.
	—	—	—	W.N.W.	W.N.W.	E.
	6 a.m.†	1.078	—	S.	W.N.W	S.S.E.
n.*	—	—	—	S.	N.W.	S.
	—	—	—	E.	N.N.W.	S.
	—	—	—	S.	N.N.W.	S.W.
	—	—	—	E.	S.E.	S.
	—	—	—	S.E.	S.E.	E.
	—	—	—	S.S.E.	S.S.W.	S.E.
†	—	—	—	S.E.	S.E.	S.E.
m.	—	—	—	S.E.	S.E.	N.W.
†	Night a.m.	0.462	—	S.E.	W.S.W.	N.
n.‡	1 p.m.†	0.732	—	N.N.W.	N.W.	S.W.
	—	—	—	E.	S.E.	E.S.E.
	—	—	—	—	N.W.	S.S.W.
p.m.¶	—	—	—	E.	S.E.	N.W.
	—	—	—	N.W.	N.N.W.	N.N.W.
	—	—	—	N.N.W.	N.W.	W.N.W.
	—	—	—	N.W.	N.N.W.	N.N.W.
.*	Night a.m.	2.401	—	N.N.W.	N.N.W.	N.N.W.
m.†	Night a.m.†	0.017	—	N.N.W.	N.W.	S.S.E.
	—	—	—	S.E.	N.N.W.	S.W.
	—	—	—	E.N.E.	N.N.W.	S.S.E.
.....		4.711	—	Per cent. of Time and V N.E. quarter..... S.E. „ ..... S.W. „ ..... N.W. „		

October 9th—10th, and disappeared October 16th and 17th. ¶ Light of October 30th—31st, ice formed about ¼ inch thick.

REPORT

ON

TRANSPORTATION ROUTES BETWEEN SAPPORO & TIDE-WATER.

BY

PROF. WM. WHEELER, B.S.

SAPPORO, JAPAN, February 20th, 1877.

To His Excellency,

HORI MOTOI,

Kaitaku Dai-Shiokikwan.

SIR:

Upon the 25th of November last, by request of Your Excellency, a trip was made from Sapporo to Shinoro, to examine the ditch canal and the Shinoro river, in view of proposed improvements thereof for navigation, the party consisting of Your Excellency, Mr. Iwafuji, Chief of Public Works, Mr. Kojima, Interpreter, and myself.

The relative advantages of constructing and operating a lock canal from Sapporo to the Barato river near its union with the Ishcari; of opening a first class highway from Sapporo to Otaru; and of building a narrow gauge railroad to either of these navigable approaches to Sapporo from the west, were also discussed. Whereupon, I was instructed forthwith to make a thorough examination of the transportation facilities between Sapporo and tide-water, by instrumental surveys of the routes toward Shinoro, and a reconnaissance of the Otaru routes; to prepare plans and estimates thereon; and to report without reservation, as my best judgment should dictate, at the earliest opportunity. It was afterwards deemed

expedient to make, likewise, an instrumental survey of the routes to Otaru, in order to obtain a more just comparison with the Shinoro routes ; and my suggestion so to do was covered by your further request that this be done immediately after the Shinoro surveys should be completed.

Now, therefore, in conformity with the instructions so received from Your Excellency, I have the honor herewith to report, and do respectfully submit the accompanying plans and estimates.

Having made satisfactory arrangements for my temporary absence from the College, a survey party was immediately organized, consisting of Mr. Kato as my principal assistant, Mr. Kojima as interpreter, who also rendered much additional assistance, and from six to eight coolies, serving as chainmen, rodmen, axemen, etc.

The field was taken December 4th, and by carrying the work forward as rapidly as the inclemencies of the season permitted, we had finished, December 28th, the surveys of the old ditch canal; of Kotoni and Shinoro rivers ; of the new cut-off canal from Shinoro to Barato river ; and thence, of the Barato, to the Ishcari river. Accurate levels of the ground, and of the water in these several channels were taken; and the depths of the water therein, and of the mud in the swamps were duly measured.

During the month of January, with the assistance of the same party, the surveys between Sapporo and Otaru were made. The features of the rocky bluffs and mountains which skirt the coast from Jenibako to Otaru were carefully noted, and the feasibility of making all ascents and descents with the least possible inclination or grade was kept constantly in

view. The survey of this line was finished January 20th, after which—my attendance being then required at the College—the levels thereof were taken by Messrs. Kato and Nasa, according to my directions. Mr. Kato has also made, at my request, the survey for a canal running straight from the junction of the ditch canal with Kotoni river, to the new cut-off between Shinoro and Barato rivers, and has done his work well.

These surveys, together with the reconnaissance of the mountain route between Otaru and Jenibako, made in company with Your Excellency on the 13th of November last, comprise the field work upon which this preliminary report is based; and they have been made with a degree of care which enables me to offer these conclusions in the belief that they are substantially correct,—at least, in so far as I am able to comprehend the true policy of the Kaitakushi with regard to opening other lines of communication with the superior harbors of the eastern coast.

KOTONI AND SHINORO RIVER ROUTES.

The distance from the canal dock of Sapporo to the Kotoni river, following the line of the ditch canal, is 17,750 feet, in which the water falls $27\frac{30}{100}$ feet.

This line is somewhat indirect, and at about half a mile from the dock it enters an extensive swamp which reaches to the north of the Kotoni river, and through which the mud is from ten to eighteen feet deep. The trees in this swamp are generally scatter-

ing, and a large proportion of those in the more densely wooded parts near the line of the canal have recently died. Your Excellency having called my attention last November to the fact of the death of these trees soon after this channel was cut, I observed that when the canal was closed by the ice on the 5th of December last, it was so much obstructed thereby, as to cause the water to overflow its banks, even as far south as the streets of Sapporo. Much of the swamp was covered from one to two feet in depth, causing the survey to be suspended until it had become frozen, and showing what has, apparently, during preceding years, produced the injury alluded to.

Following the course of the Kotoni and Shinoro rivers, by the way of the short cut-off near Shinoro village, and the longer one from the Shinoro to Barato river, we find the distance from the ditch canal to Barato river to be 31,634 feet, and the fall of the water $18\frac{11}{100}$ feet; thus making the whole distance from the dock to Barato river by this route, 49,385 feet, or $9\frac{353}{1000}$ miles; and the total fall of the water, $45\frac{71}{100}$ feet.

It will be observed by the accompanying map, that the course of the Kotoni and Shinoro rivers is exceedingly tortuous. Their width varies from fifteen to fifty feet, and depth from two to five feet,—the prevailing width being about twenty-five or thirty, and depth three to four feet. At the lower end of the canal the banks of the river are about one foot above mean water, continuing so through the swamp for about two miles, when the stream gradually falls below the level surface of the country, until at Shinoro village and beyond, the banks are from six to ten feet above mean water.

The velocity of the current averages from two to three miles per hour, while for short distances, as at many of the very abrupt turns, it is much greater; so that it is frequently almost impossible for boatmen to prevent the dug-out canoes which are now used thereon, from striking the banks of the stream in passing such points.

It seems hardly necessary therefore to say that any system of steam navigation in the present channel—either by the use of steam transports, or tug-boats—is impracticable.

I am also equally assured, after a careful study of the case, that any attempt to straighten or otherwise to improve the channel for steam navigation, or canal operation would be utterly inexpedient. 1. Any undertaking of that nature, sufficiently complete to accomplish its purpose will involve an expense equal to that of an independent channel throughout, or of a lock canal such as will be hereafter described. 2. If done, the velocity of the current will be materially increased thereby, causing the washing down of the banks in some places, and producing shoals in others. 3. The annual spring floods will tend constantly to deviate from the artificial channel, and eventually to reproduce its natural condition.

All these difficulties would be certain to follow to a greater or less extent, so that I must respectfully recommend that the project be discarded.

The construction of a tow-path for the use of horses in propelling river boats is quite as impracticable as are the measures already mentioned. 1. As already intimated, the crookedness of the channel, and the velocity of the current would render either a loaded or empty boat almost unmanageable when drawn by

horses as a canal boat. 2. The current coming *against loaded boats chiefly*, at the rate of two and a-half miles per hour, it would require precisely four times the power that would be necessary to draw the same boat and load in still water, at the ordinary speed of two and a-half miles per hour. This objection applies with equal force to the propulsion of boats against the current in any stream or canal, whether by men, horses, or steam. 3. A tow-path, to be of practical service, should be constructed closely along the edge of the channel, at a nearly uniform hight not exceeding four feet above the water. The annual freshets in the lower portion of the Shinoro river would overflow such a path, and the increased power of the current cause serious injury thereof. 4. The prime cost of a tow-path would exceed that of the direct lock canal hereafter to be described.

Other cogent objections might be urged against either of the foregoing projects; but in the light of all my own study and observations thereon, I consider any one of the difficulties stated above, to be a sufficient ground for Your Excellency's disapproval thereof,—especially in view of the superior claims of other plans to be considered.

LOCK CANAL ROUTE FROM SAPPORO TO BARATO RIVER.

The Kotoni and Shinoro rivers having proved to be unfit for successful navigation, we next consider the improvement of the ditch canal as part of a com-

plete lock canal route from Sapporo to Barato river, —the remainder of the route to run straight from the junction of the old canal with Kotoni river, to the Barato river near the lower end of the cut-off, as shown by the red dotted line upon the accompanying map.

The distance from Kotoni to Barato by this line is 17,150 feet, and the fall 18$\frac{11}{100}$ feet. The whole distance, therefore, from Sapporo, is 34,900 feet, or 6$\frac{61}{100}$ miles; which is 2$\frac{7}{10}$ miles shorter than by the river route.

The advantages to be gained by following the old canal as far as Kotoni, instead of adopting an air line throughout the whole distance, are threefold. 1. It will be of great assistance in transporting lumber and other materials required in the construction of the new work. 2. Its channel will afford good drainage while the works are in progress. 3. The labor of removing trees and stumps along that portion of the line has already been performed to a great extent.

The experience of all western countries, where canals were in common use for freight transportation, previous to the general introduction of railroads, has proved—as common reason fully demonstrates —that canals which connect points of different elevation, should be divided into several level portions, communication between which is effected by means of locks. A lock consists of a basin or inclosure in the canal, usually made just large enough to receive one boat. This basin is provided with strong gates at each end for the entrance and exit of boats, and for retaining water in the lock at different elevations: also with water valves by which

the lock can be filled or emptied for the purpose of raising or lowering the boats as they pass from one level to another. The quantity of water in the canal is regulated by a weir or overflow in each level. The value of these expedients—to avoid waste of power by the resistance of a current; to prevent injurious washing of the water-way, and the destructive overflow of freshets; and to employ the water with the utmost economy—is too evident to require further explanation; and they may be considered as absolute necessities in this case.

The large swamp before mentioned extends about two miles north of the Kotoni in the line proposed, making nearly five miles of swamp traversed thereby, which is poorly adapted for canal construction and maintenance. The plans upon which my estimates for this portion of the route are based, provide for a row of sheet-piling upon each side of the water-way; said sheet-piling to consist of three-inch planks driven to a proper depth, and supported by a line of timber piles, driven twelve feet apart to a hard bottom, and capped with a course of timber one foot square. The locks are to be eight in number, constructed with heavy timbers upon a pile foundation, —stone being too expensive in this locality—and the sides and bottom thoroughly caulked, so as to be practically water-tight.

The general dimensions of the proposed canal are to be mainly as follows:—

Width at surface of water, in hard land, ... 25 feet.

Width at bottom, in hard land..... 14 feet.
(Sufficient for two boats to pass, in opposite directions.)

Width between sheet piling, in swamp land,	16 feet.
Depth of water,	3½ feet.
Width of tow-path for horses,	9 feet.
Length of Lock chamber	60 feet.
Width of Lock chamber	8 feet.
Lift of Locks, from one level to another	from 5½ to 7½ feet.

The boats should be from fifty to fifty-five feet long, seven feet wide, and draw about two and one-half feet of water when loaded ; thus having a capacity of twenty to twenty-five tons. Such a boat with a full lading may be drawn by one horse at the rate of two miles an hour, not including the delay of passing through the locks.

The dock at Sapporo should be deepened, and made wide enough to turn about readily, therein. Dock accommodation should also be provided at the Barato end of the route, for which purpose a part of the new cut-off can be made suitable.

It was originally my intention to make this cut-off a part of the canal route, as shown by the full red line on the accompanying map. Learning afterwards, however, from Mr. Iwafuji, that the land in its vicinity is frequently covered by the flood waters of the Ishcari and its branches, it became necessary to establish the water way of the proposed canal mainly above the natural surface of the ground in that vicinity. Hence the channel of the cut-off was discarded in favor of he direct line.

Such is an outline of the plan proposed for the improvement and construction of a route which appears to be the least objectionable of those suggested between Sapporo and the Ishcari river. Further

allusion will be made to its merits as compared with those of other plans now to be considered.

HIGHWAY FROM SAPPORO TO OTARU.

In attempting to select the best route for a first class country highway between Sapporo and Otaru, it has been my aim to secure the shortest possible time consistent with the following points, to wit:—

1.—Easy grades, or gradual inclinations in making all ascents and descents.

2.—Economy of construction, by avoiding as much as possible extensive swamps, heavy excavation and embankment, and unnecessary rock cutting.

3.—Durability of roadway, by keeping above the reach of ordinary storm waves along the precipitous coast, and by protecting the most exposed parts of the road from the sea, by permanent retaining walls of stone.

4.—The opening up of valuable land between Sapporo and Jenibako, for settlement and improvement.

5.—Non-disturbance of houses, as at Jenibako and Otaru; at the former of which, a saving of distance, and immediate access to land valuable for building, is effected; while at Otaru, distance is likewise reduced thereby, and steep grades avoided.

The route thus obtained, where varying materially from the old road, is represented by the full red line upon the accompanying map of "Transportation Routes between Sapporo and Otaru."

Beginning near the west end of Sorachi street,

and running in a line nearly direct to the foot-hills near Santarobetsu—a little more than half way to Jenibako—a reduction of 7,650 feet, or 1 $\frac{450}{1000}$ miles is made from the distance by the old highway, reckoning from the Capitol by each route, to their intersection near Santarobetsu. The line crosses in this distance about two miles of swamp land; the remainder being well adapted for settlement. Thence the route passes through the foot-hills near Santarobetsu, as shown on the map, makes a very easy descent of the high bluff beyond; follows the line of the old road for about one mile just before coming to Jenibako; passes Jenibako upon the sloping table-land lying between the village and the mountains; and reaches the sea coast a little way beyond Jenibako toward Otaru. An additional reduction of 1,930 feet, or $\frac{37}{100}$ mile, is effected, from Santarobetsu to this point.

Thence the route follows, in the main, the line of the coast to the new wharf now building at Otaru. Along the most precipitous and exposed parts of the rocky bluffs, the road is to be located at a nearly uniform hight of sixteen to eighteen feet above tide water, and therefore to be, in general, somewhat higher, and farther from the water's edge than the present pack-horse road at the foot of the bluffs.

The whole length of the proposed highway from Sorachi street to Otaru wharf is 21 $\frac{317}{1000}$ miles. The distance from the Capitol to the wharf by the same route is 21 $\frac{630}{1000}$ miles; and the distance between the same points by the old road is 23 $\frac{508}{1000}$ miles. The whole reduction, therefore, is 1 $\frac{878}{1000}$ miles, or 9,868 feet.

The steepest grade required upon any portion of

this route is three feet rise in one hundred feet. The general width of road-bed for which the estimates are computed, is thirty feet. When the line passed through swamp land, however, the width may be reduced to twenty-four feet, when suitable materials for construction are obtainable only at great expense. Along the most difficult portions of the sea-coast, also, the roadway may well be reduced to not less than twenty feet, in addition to the width required for a good ditch or gutter for drainage along the land side. The full width of thirty feet is to be maintained, however, at all places where the cost will not be made excessively large thereby.

It is proposed to construct that part of the road which passes over soft swamp land, upon a foundation of fascines, or bundles of branches and small saplings, laid in two or more courses at right angles to each other, thus providing a cheap, substantial, and durable foundation.

The "dry rubble walls" provided for in the estimates, to protect the roadway from the waves, are to consist of large blocks of uncut stone, laid in irregular courses without cement, and with a good general bearing upon each other from the face to the back of the wall. The thickness of the wall at the base should be about one half its hight, and the foundation courses should be protected by rip-rap, or random stone. A wall of this description is not only cheaper, but also much stronger and more durable than walls of cut stone laid with a bearing of only about one inch from the face according to a common Japanese custom, adopted in some of the great walls at Tôkiô.

As a general rule, however, where the line and character of the coast permits, it is better to make the

road-bed chiefly in excavation, instead of building out upon an earth or broken stone embankment; because greater natural stability of the road-bed will be thereby secured, and the wall that might be necessary to sustain the natural bank above the road, would be less expensive and less apt to be destroyed, than a wall required both for the purpose of supporting the road on an artificial embankment, and for its protection against the encroachment of the sea.

It will be seen by the accompanying estimates that the cost of the road along the coast from Jenibako to Otaru, is nearly twice as great per mile, as that between Jenibako and Sapporo; owing to the quantity of rock excavation and masonry required. Beyond this consideration of cost— if the improved methods and appliances be used which so extensive a work would justify—there are no insuperable, or very serious, difficulties to be encountered.

New tunnels should be built in place of those upon the old road. They should be about eighteen feet wide by fifteen feet high, and should be located above the reach of storm waves.

The impossibility of securing a practicable route above the cliffs on this coast; or over the mountains; any line away from the shore between Otaru and Jenibako, was made too clearly apparent at the time of our reconnaissance for such a route—made November last in company with Your Excellency—to require further comment here. And the impressions which I then received, of the relative impracticability of an inland route, were fully confirmed during a recent excursion to the survey station on the summit of Mt. Tiene (made January 30th, in company with Pres. Clark, Prof. Penhallow, and eleven students of

the college), from which an extensive view of the country in consideration was obtained.

The question may now arise—whether, as a measure of economy, it will be wiser policy to rebuild and improve the old road, mainly in its present location, and to rely upon the current expenditure of such sums of money as may be necessary to repair damages by storm along the coast; than to expend at the outset, the full sum required to render it secure from injury, except by use.

If by the opening of other routes for the transportation of heavy freights—either by a canal to the Ishcari, or a railroad to Otaru, or by the construction of a railroad connecting with the harbor at Mororan —the business here to be provided for be simply that of local trade and travel; it would become possible, and, under either of the two railroad schemes, probably advisable to fulfil that purpose by the expenditure of a less sum upon this route.

This arrangement would be effected by the improvement of the old road from Sapporo to Jenibako, and the construction of a new highway along the coast, which, as compared with that provided for in the estimates, should be made equally substantial and secure, but of less width—to be sufficient, however, for the passage of freight wagons going in opposite directions. This alternative could probably be carried out for about one-half of the estimated cost of the larger work, and will be further considered when we come to a comparison of the several projects.

Viewing now, however, the proposed highway to Otaru as the main thoroughfare between Sapporo with its dependencies and the chief shipping port on the west coast, and therefore—in case no further

communication with the east coast be established—between the capital of Hokkaido and the rest of the empire, I think Your Excellency will agree that the general character and quality thereof herein described, as to directness, grades, and durability, for the accomodation of a heavy wagon traffic do not exceed the proper requirements of such a route. Whether the same degree of excellence can be maintained, and the general interests of the government equally subserved by a less permanent work supported by constant renewals and repairs, seems hardly to require further consideration. The following points are clear upon the subject, and need no explanation :—

1.—The question of distance must be decided at once in favor of the new route.

2.—The same degree of excellence cannot be *maintained*, if the work remains liable to constant damage, along the sea coast, by storms.

3.—A route that is *not always* reliable is *never* reliable.

4.—It is an unwise economy that would permit the only line of communication between an important capital and its chief seaport, to be subject to repeated interruptions.

5.—One route that can be depended upon at all times, is better than many routes that can be relied upon at no time.

6.—Any policy which applies money continually to temporary expedients for the accomplishment of a lasting necessity, is a policy involving the waste, and not the economical use of wealth.

7.—A policy which puts every dollar where it may render a permanent service, is a policy for the application of wealth solely to productive uses.

Hence, I would most respectfully suggest, that whatever be the amount appropriated for this route, or for any other route of such exclusive importance; let every dollar be so applied that it may render a lasting service. Let the most economical plan of sufficient and permanent utility be adopted for a guide, and whatever be the original, or subsequent annual outlay, let it be devoted to the thorough and substantial execution of that part of the work requiring the first attention, in accordance with well devised and complete methods. "Whatever is worth doing, is worth doing well." If the sum now to be expended upon this route be sufficient only to build a mile let the worst mile be selected, and made the best and most permanent in the whole distance; or, however much distributed, let it be devoted to improvements which shall be of a more enduring character than to be washed away by the next severe storm.

This policy, if adhered to, can result only in positive, progressive improvement; and at the close of a generation will have involved less expenditure for construction and maintenance; less difficulty, delay and expense in the transportation of public and private commodities; less annoyance and danger to travellers.

It will encourage permanent settlement, and tend to cultivate and establish a spirit of systematic and substantial improvement.

RAILROAD ROUTE BETWEEN SAPPORO AND OTARU.

Believing the question of transportation to which Your Excellency had called my attention, to be one of the highest importance, in which every part should, from the outset, be considered with reference to the whole system of the future; and knowing also that railroads have proved to be, not only the most valuable means of inter-communication between well established communities, as in Europe and the older American states, but that they are regarded also as the true pioneers of colonization—the chief instrumentality in opening up vast territories in western America, South America, India, and Australia—in sections of country totally devoid of civilized life, and less rich in mineral and agricultural resources than is Hokkaido:—bearing these facts in mind, I felt it my duty to suggest to Your Excellency that a faithful examination of the subject of railroad communication would possibly afford valuable information upon the subject in hand. This proposition having received Your Excellency's approval and encouragement, I made the surveys of the routes herein discussed, a sufficient basis for preliminary plans and estimates for the construction and equipment of a railroad, either to the Ishcari or to Otaru. I have also endeavored to weigh justly the advantages and possibilities of these several routes, together with those of certain proposed lines of communication with the better harbors of the east coast, both in their separate and combined capacities for fulfilling the immediate and prospective wants of Hokkaido.

As the result of the best light which I can bring

to bear, it is now my opinion that the construction of a railroad to connect with any of the inferior shipping accommodations of the west coast, would, at the present stage of affairs, be advisable only as an alternative measure—to be adopted only upon a positive demonstration that the opening of a route to the more excellent harbor at Mororan, is, economically speaking, impracticable. To this alternative I shall have occasion to refer again.

I have, however, selected that route which appears to offer the best inducements for railroad communication with the western sea, besides affording the greatest local advantages, and have prepared plans and estimates thereon, which are submitted herewith.

For good and sufficiently apparent reasons, I have considered it unnecessary to discuss the subject of railroad communication with the Ishcari river, at any length ; since most of the objections which condemn the policy of a canal—stated in the following pages—apply with almost equal force to railroad connections therewith.

The proposed railway route between Sapporo and Otaru follows approximately the line of the proposed highway, with the exceptions shown upon the accompanying map by red dotted lines, indicating changes which should be made for a railroad location.

It is to be presumed that in the event of the adoption of this plan, the highway would, in the main, be made entirely adequate to meet all local demands upon it, by such a system of permanent improvements as has already been described; in which case the railroad would be constructed along the declivitous portions of the sea coast bluff, at an elevation sufficiently above the improved highway to cause no

interference. This arrangement would involve no expense for the protection of the railroad by a sea wall, since the intervening highway would afford ample security.

The general plan upon which the estimates and recommendations concerning railroads herewith submitted are based should, as a matter of course, represent and conform to that system which seems best adapted to the resources and requirements of the whole of Hokkaido, both for the present and future; since the question of gauge, ultimate grades, weight of rolling-stock, etc., to be adopted and provided for, must be fairly and wisely determined, according to the requirements of the whole future system, before any decisive steps for any part thereof can be intelligently considered.

The first, and by far the most important element to be determined with regard to any railroad system, is that of *gauge* or the distance between the rails which constitute the characteristic feature of the system.

Without entering at any considerable length upon the history of gauges, or scientific principles which, in recent times, have been developed—giving rise to radical changes in the theory and practice of railroad construction and operation—I will state briefly the experience and the tendencies which are obtaining in other countries, especially under the rising school of railroad experts and engineers.

When the first really successful locomotive was constructed about sixty years ago, it was made for a gauge of four feet, eight and one-half inches, which was then the distance between the wheels of the coal wagons used upon the tramways among the English

coal mines. Thus, without any good reasons deduced from experience or theory, this was generally adopted as the standard railroad gauge of that time, and has so continued in Europe and America, until within a very recent date. The few exceptions thereto, which were constructed upon gauges of seven, six, and five and a-half feet respectively, have in nearly every case been reduced at great expense to the above standard.

Within the past ten years—since the beginning of the progressive era in the history of Japan—the experience of half a century of railroad enterprise has proved to the general satisfaction of careful observers and practical experts that the original gauge is, by far, too wide for the traffic upon the great majority of the railroads in operation, even in the most flourishing countries. A vast extent of the so-called "narrow-gauge" roads have sprung up in consequence, for which systems the following advantages are claimed upon strong grounds :—

1.—Less capital is required for the railway.

2.—Less capital is required for the rolling-stock.

3.—The proportion of non-paying to paying-load is reduced.

4.—Steeper grades and sharper curves are admissible.

5.—Greater economy of operation is secured.

6.—The cost of maintenance and repairs is reduced.

7.—The capacity is equal to any ordinary traffic.

8.—Equal safety and convenience are insured.

Among the many systems of narrow gauge railroads which have been constructed within the past decade, upon this evidence, are the following :—

Canada, British America, width of gauge, 3 ft. 6 in.
Norway, Sweden & Russia, „ 3 „ 6 „

Japan, main land,.....	width of guage,	3 ft. 6 in.
Australia	„	3 „ 6 „
British India.....	„	3 „ 3 „
South America	„	3 „ 3 „
United States of America,	narrow guage	3 „ 0 „
	standard	

In addition to these, narrow gange railways are in successful operation in Belgium, France, Italy, Switzerland, Austria, Germany, and other European States.

As illustrating "the rise, progress, and success of the new system" in America,—in whose wild territories of the west, as also in India, Australia and South America, it is especially considered the forerunner of settlement and civilization,—I respectfully refer Your Excellency, and such officers of the Government as may be interested therein, to Mr. Sato's translation of some of the most important portions of a small pamphlet upon "Narrow Gauge Railroads in America."

Since the publication of this work however,—only two years ago—a still further reduction of gauge has been strongly recommended for branch roads, and for complete systems whose required capacity is somewhat less than that of the standard gauge of four feet, eight and one-half inches. The "narrower gauge" system, so-called, has received the commendation of railroad men of undoubted authority in Europe and America.

The following are some of the roads of this class, most of which are already in operation, and have proved successful beyond the most sanguine expectations of their projectors:—

		ft.	in.
Broelthal railway, Germany, for passengers and freight,	gauge,	2	7
Sevel mining railroads, Europe,	„	2	6
Festiniog railway, Wales, for passengers and freight,	„	1	11½
Chatham Docks railway, England, for passengers and freight	„	1	6
Woolwich Arsenal, and Portsmouth Dock, England,	„	1	6
Peekskill railroad, New York, United States,	„	2	0
Billerica and Bedford railroad, Massachusetts, United States, for passengers and freight,	„	2	0

and others of less importance.

The most prominent line of this class in America is the one last named, with which I was connected as Engineer in Chief previous to my departure for Japan. Having had occasion, in that capacity, to testify before the State Legislature—by which body, a law authorizing the adoption of the narrower gauge of two feet was subsequently enacted,—the following abstract from the evidence then submitted represents the conclusions to which a comparative study of the several gauges then led :—

"Not only theory, but practical experience as well, demonstrates that the narrower gauge of twenty-four inches is entirely practicable in all respects, and that for the distinctive service which it is intended to perform (for branch lines, or for complete systems of moderate requirements), it possesses undeniable advantages over either of the broader gauges :—

1.—It admits of a degree of speed, safety and convenience equal to that afforded by the broader gauges.

2.—The cost of construction and equipment does not exceed one-fifth that of the standard (four feet, eight and one-half inches), or one-half that of the three feet gauge.

3.—Its capacity for traffic is much greater than that of the broader gauges, in proportion to the capital cost.

4.—The proportion of non-paying load is less, being approximately two, three, and four times the paying load for passenger cars of the two feet, three feet, and the standard gauges, respectively. For freight traffic, where strength, instead of dimension is the limiting element in cars, the comparison is still more favourable to the narrow gauge.

5.—In consequence of the preceding fact, sharper curves and steeper grades can be overcome with the same expenditure of power per ton of paying load.

6.—Hence the cost of transporation, *pro rata*, is less.

7.—The bearing weight upon each wheel is much reduced ; hence the injury to rolling-stock and rails is less, and the cost of maintenance and repairs diminished.

8.—It offers to all districts quick and cheap communication with the whole world of social and commercial intercourse, developing new and richer fields for the industry, the maintenence, and the wealth of individuals and nations."

The estimates for this railroad (Billerica and Bedford), including equipment, station buildings, etc., were less than $6,000 per mile ; and with the exception of grading and masonry—which were derived from other similar works then in hand—were based upon proposals made by manufactures and builders,

some of the most important of which I have at the present time.

These prices, I am informed by the latest advices from my successor, exceed, generally, the actual cost of the work, as far as then completed, so that I am able to offer the accompanying estimates in the fullest confidence.

The general cost per mile of the three principal gauges alluded to, including equipment, turnouts, station buildings, etc., for a single track constructed according to the American practice, with labor at $1.50 per day, and iron at $50.00 per ton, ranges approximately as follows :—

Standard Gauge, ...4ft. 8½in. $20,000 to $40,000.
Narrow Gauge Standard, 3ft. 0in. $10,000 $20,000.
Narrower Gauge, ...2ft. 0in. $ 5,000 $10,000.

The approximate capacities of these several gauges for transportation of heavy freights, such as coal, grain, lumber, etc., upon a level, and upon grades of 60 and 100 feet per mile, using locomotives of an average weight, are shown in the following table :—

Width of Gauge.	Locomotive. Weight on Drivers.	Eight-Wheeled Car. Weight of Empty Car.	Eight-Wheeled Car. Capacity.	Load per Train, in gross tons. Weight of Cars and Lading. Level.	Weight of Cars and Lading. 60 ft.	Weight of Cars and Lading. 100 ft.	Weight of Paying Load. Level.	Weight of Paying Load. 60 ft.	Weight of Paying Load. 100 ft.	Ratio of Non-Paying to Paying Load.
4 ft. 8½ in.	24 tons	8 tons	10 tons	1280	280	168	711	156	93	80 to 100
3 ft. 0 in...	18 ,,	4 ,,	8 ,,	960	210	126	640	140	84	50 to 100
2 ft. 0 in...	12 ,,	2 ,,	6 ,,	640	140	84	480	105	63	33 to 100

By using heavier locomotives, greater loads can be readily transported upon either gauge. The daily or

annual capacity of a single track is determined by multiplying the number of trains passing each way for the given time, by the "paying load" upon the maximum rising grades which are to be ascended in the given route. The number of trains that can be conveniently managed upon a single line, twenty miles in length, and upwards, with a liberal number and length of turnouts, and an effective signal system does not vary materially with the different gauges; and ranges from twelve to twenty daily each way, or possibly more—depending very much upon the character of the traffic.

Now what is the gauge best adapted to the wants of this island, being at the same time the least burdensome in its introduction, maintenance and operation?

The railroads of Yesso can never have direct connection with those of the main land. Therefore no regard should be had for uniformity therewith for the sake of continuity.

No great trunk routes with an extensive system of feeders can ever be required upon the limited territory of this island.

In fact, it is impossible to estimate, with any degree of accuracy, the ultimate amount of service which this or any other system of railroads will be called upon to perform. Neither would it be of essential importance to do so, since by the addition of a second track, or of any required number of parallel tracks, any desired capacity could be provided, as the increase of business should require. And in this fact lies a very important feature of the narrow gauge system, namely: its prime cost is within the means of the most limited resources; and whatever be the future amount of service required,

the requisite number of tracks may be added as the business increases, and the work still be performed at the same degree of economy.

The traffic of the future, in this case, promises to be of an abundant, yet compact nature,—consisting of the transportation of coal, lumber, agricultural produce, silk, skins, leather, and manufactured articles from the interior to the shipping ports ; and the return of iron and iron ore, rice, tea, general merchandise and supplies.

Now therefore, in consideration of the general facts and principles stated above, I have selected a gauge of two feet and eight inches as the basis for my preliminary estimates, and recommend its adoption for the future railroad system of Hokkaido. It is sufficiently narrower than the United States narrow standard to effect a material saving in cost, without lacking in capacity or efficiency ; sufficiently flexible to adapt itself to the sharp curves and steep grades required in country of rocky and mountainous character, and at the same time, enough wider than the narrower gauges of eighteen and twenty-four inches to command the confidence which conservative minds are apt to lack in the extreme measures and appliances which come through constant and progressive development.

I have yet to learn, however, of any road of the narrowest gauges, that has proved insufficient for the increased traffic which invariably follows the establishment of railroad communication ; and would not hesitate to approve the adoption of a narrower gauge, should the Government be equally convinced of the economy and general expediency thereof.

The rails proposed for the railroad to Otaru are such as are in use in America for the three feet gauge, weighing thirty pounds per yard, to be laid upon cross-ties placed twenty-two inches from centre to centre.

The steepest grade will not exceed 150 feet per mile, and can be reduced to 125 feet at a small additional cost. The maximum grades upon several of the three feet gauge roads of the United States are from 200 to 300 feet per mile ; which, however, are too great for a heavy traffic.

The weight of locomotive to which the rails are intentionally adapted, is about sixteen gross tons upon the driving wheels. The power of such a locomotive is shown approximately in the following table.

Gauge.	Locomotive.	Weight on Drivers.	Eight-Wheeled Car, Freight.		Load per Train in gross Tons.								Ratio of Non-Paying to Paying Load.
					Of Cars and Lading.				Of Paying Load.				
			Weight, Empty.	Capacity.	Level.	60 ft.	100 ft.	150 ft.	Level.	60 ft.	100 ft.	150 ft.	
32 ins.	16 tons		3 tons	7½ tons	810	186	120	80	486	112	72	48	40 to 100

Equipment, station buildings, and a complete plant for the operation and maintenance of the route under an extensive traffic are duly provided for.

ESTIMATES AND CONCLUSIONS.

The estimates for the three routes herein discussed are stated in detail in the accompanying appendix, the total being respectively as follows :—

1.—*Lock Canal from Sapporo to Barato River,*

$6\frac{61}{100}$ miles, at $11,086.47 per mile,..... $ 73,281.60

2.—*New Highway from Sapporo to Otaru,*

Sapporo to Coast Line $11\frac{333}{1000}$ miles, at $6,104.36, ...$ 68,265.07

Along Coast to Otaru, $10\frac{133}{1000}$ miles, at $11,653.50, ...$118,084.89

Total..... $186,349.96

3.—*Narrow Gauge Railroad from Sapporo to Otaru,*

including equipment, $21\frac{333}{1000}$ miles, at $12,408.07,..... $265,172.82

To these may be added the alternative before mentioned :—

4.—*Straightening and Rebuilding Old Road from Sapporo to Jenibako, and Constructing a narrower Highway along the Sea Coast,*

estimated at $100,000.00

Now with regard to the policy to be adopted, in reference to these several projects, for securing to Sapporo and its allied interests, an effective system of internal communication, I shall be brief.

And first, the project for a canal of any kind to the Ishcari, I cannot recommend upon any consideration, for the following reasons :—

1.—Both the Canal and the Ishcari river would be closed by ice during nearly five months of every year.

2.—The annual floods which cover the country near the Ishcari, would cause frequent damage, and endanger the safety of the canal embankments.

3.—The large quantity of lumber used in its construction would be subject to constant decay, thus requiring great expense for renewals and repairs at a season when the business of transportation would be interrupted thereby.

4.—It passes through a section of country entirely incapable of improvement for settlement and cultivation.

5.—It has no immediate connection with a deep sea harbor.

6.—It would require several transfers of cargo, namely :—From sea vessels to river boats ; from river boats to canal boats ; from canal boats to warehouses.

7.—It is adapted only to a slow freight traffic, and therefore provides no additional facilities for the transportation of passengers, mail, etc.

8.—It offers no conveniences of local travel and intercourse for the people, and extends no direct aid to settlers.

9.—It aims to revive a system of transportation that has become almost entirely obsolete in other countries, where formerly in use. Among western nations, canals have been generally abandoned, and railroads frequently constructed along the same general line. It would probably be impossible, at the present day, to raise a single dollar in America, for a canal for inland communication. It may also be

observed that this substitution of railroads for canals was made long before the introduction of the more economical narrow gauge systems.

In view of these facts, I am confident that its construction would prove to be an unwise and costly measure,—that it would never fulfil the requirements of the Government or the wants of the people with efficiency, and that other and better means of transportation would be hereafter necessary for the service which this would fail to perform with satisfaction. Hence I most respectfully recommend that the project be abandoned in favour of some one of the superior expedients to be considered.

Next, concerning a new highway from Sapporo to Otaru. Good roads are of more importance than canals, and must not be disregarded in any system of inter-communication, since it is by them that the general convenience and prosperity of the people are directly secured and promoted. Whatever may be done in other directions, the establishment of a permanent and reliable route between Sapporo and Otaru; and, at least, the rebuilding of the coast road to a passable width, as proposed by the "alternative" plan, is an almost absolute necessity for local convenience, and for easy communication between the capital city and the chief port of the west coast.

Now, if, to the cost of this necessary undertaking, we add the cost of the proposed canal, and its equipment which the estimate does not cover, the sum will be sufficient to construct the new highway throughout, in accordance with the complete plan therefor. This measure, as compared with the canal project, will, upon the whole, furnish a route of much

superior efficiency, at the same cost, taking all seasons and uses into consideration; of greater convenience to the public; involving a smaller outlay for expenses; presenting inducements for the more general use of wheeled vehicles by the people; giving access to a section of excellent land for habitation and improvement; subject to no serious or long continued interruptions; and involving no capital expenditure that will be rendered useless by the establishment of railroad communication with either coast.

This plan is, therefore, superior to that for a canal. By the use of substantial wagon teams and sleds, each in its season, under an efficient management, this line of direct communication with the wharf and warehouses at Otaru, over a hard road-bed and easy grades, will enable a large amount of government and private freight to be transported, and afford the necessary convenience and safety to travellers, and to the people living along the route.

Hence, the building of a substantial highway according to one of the plans proposed, may be considered a necessity; and as such, I respectfully commend it to your favour.

It is clearly apparent, however, that the best system of highways alone is entirely inadequate to introduce and to stimulate profitable industries, or to develop the natural wealth of Yesso. And I hardly need add that the experience of the whole civilized world proves beyond controversy that by railroads only can the people of the island make any material progress in the creation of wealth and the production of revenue; and that without them, no ordinance or power of government can induce the general immigration of permanent and enterprising colonists.

Lord Bacon, an illustrious English philosopher, most truly said, "There are three things which make a nation great and prosperous,—a fertile soil, busy workshops, and *easy conveyance* for men and commodities from one place to another." Certainly the soil of Hokkaido is sufficiently fertile. Her coal measures, and the iron ores of Nippon, await only "easy conveyance;" and the establishment of "busy workshops" cannot fail to follow. Coal, lumber, agricultural produce, and the whole range of manufactured products must have "easy conveyance" before they can be endowed with value: and until they have a tangible value, no power on earth can create prosperity out of them.

Another has said that "the opening up of the internal communications of a country is undoubtedly the first and most important element of its growth in commerce and civilization." Japan is not so far behind the world in acquired wealth or material progress, nor so favoured by natural endowments, that she can afford to forego, in her competition among the nations, the fruitful benefits of a wise policy of permanent improvements,—the key to enduring prosperity.

Only about a century ago Great Britain had a smaller population, less available wealth, inferior educational facilities for the masses, and fewer examples. Merchandise was carried by pack-horses over bad roads, and domestic commerce was well nigh impossible. Her coal and iron mines were but little worked; her industries were established greatly by foreigners; she sent abroad for skilled workmen; iron was imported. But the steam engine and locomotive originated within her realm: her coal and

iron mines were worked thereby; the products thereof and of the countless manufactures which immediately sprang up, were transported with speed and economy to profitable markets; and now she is surpassed by no country, of like extent and population, in wealth and prosperity. Her railroads, connected with her marine transportation, have created, in a large measure, her wealth, and they maintain her prosperity. Sixty years ago she adopted this policy: "Let the country but make the railroads, and the railroads will make the country."

During the last half century, a million of square miles have been colonised through their agency in the United States, and the people living therein contribute annually nearly one-half the products of the nation. Every railway station is a practical school of industry, attention, and punctuality, quickening the whole people to activity and enterprise.

The estimate which is submitted for a railroad between Sapporo and Otaru is intended to be liberal, and the capacity is ample for the requirements of any line in Hokkaido, or in even a more extensive country.

With my present conception, however, of the eastern coast, I cannot advise its construction as a part of the proper route for railroad communication between the interior and tide water. All the natural conditions of Yesso and its harbors seem to point to Mororan as the proper seaport for the establishment of commercial relations with other lands.

1.—It is evidently a safer and more commodious port than is the harbor at Otaru.

2.—It is from one to two days nearer to Tôkiô and all the important shipping ports of the world.

3.—Its approaches avoid the unfavorable current passing eastward through the straits of Tsugaru.

4.—It is upon the lee shore or sheltered coast of the island.

5.—The eastern coast is more free from deep snow ; and land communication therewith would be less liable to interruption.

6.—I am informed that the fisheries and other natural resources of the eastern coast are more extensive, and the exports liable to exceed those of the west coast.

7.—The coal mines at Horomui present an immediate field for profitable work, and the shipment of their product should be by the most direct and convenient route.

Now the general direction of the trade of any country, and its success, is determined very largely by the natural advantages which present for the establishment of transportation routes, of which the termini are of first importance. If these natural lines and ocean ports are disregarded, no amount of human effort can cover the mistake. It is in this light that the most prosperous and successful seaport cities of the world may be considered as works of nature which no course of legislation could effect or entirely subvert.

Hence, in establishing the main line for communication with other lands, that harbor which lies in the natural channel of trade, viâ the high seas; which affords the best shelter and anchorage for vessels, with a safe shore suitable for the construction of wharves and warehouses, should be adopted for the union of land and marine routes.

Such, if I am rightly informed, seems to be the character of the harbor at Mororan. The true solution, therefore, of the problem of communication

between Sapporo and tide-water seems to be, —by constructing a railroad to Mororan which shall constitute part of a through line from Horomui; which plan has been under the consideration of the Government heretofore. This provision for the transportation of through freight to and from the capital and its vicinity, would only necessitate the rebuilding of the Otaru highway after the cheaper but substantial manner prepared in the alternative plan.

Upon the important point of the cost of transportation, it may be stated in general terms, that, at the present prices of labor and materials in America—men at $1.50 to $2.00 per day, horses the same, and coal at $8.00 to $10.00 per ton,—the transportation of general freight by wagons upon a first class country highway costs from fifteen to twenty-five cents per ton per mile; and by railroad from one to three cents per ton per mile. The cost of carrying coal, lumber, grain in bulk, etc., by railroad is much less, as is shown by an extract from the report of the Reading Railroad Co., of Pennsylvania, U. S., for 1874, wherein is found a "Statement of the cost of hauling coal per round trip of 190 miles from the coal regions to tide-water, and back with empty cars, transporting average loads of 646.2 tons, and average through loads of 522.6 tons of 2240 pounds each." "The average cost of the trip is $159.34. Dividing this by the 190 miles, and again by the average load 646.2 tons, the the cost on the round trip is $\frac{13}{100}$ of a cent per ton per mile; or, taking the trip at 95 miles, but with the same total cost, including taking the empty cars back, it is, upon the average through load of 522.6 tons, $\frac{33}{100}$ of a cent per ton per mile." Doubling this

for other expenses, loading vessels, waste and contingencies, – one cent per ton per mile, or say $1 per ton from coal region to tide-water would pay the company a profit of nearly forty cents on each ton for transportation alone. If the profits were received upon the sale of coal, the cost of transportation would be reckoned at sixty cents per ton for the whole distance of 95 miles.

The Pennsylvania Railroad's charges upon the whole of its freight business was $1\frac{43}{100}$ cents per ton per mile : while the charge for coal upon the same road and its branches—including profit—was $\frac{82}{100}$ of a cent per ton per mile.

I have now presented the results of my examination of the projected transportation routes between Sapporo and tide-water on the west ; and, in conformity with your request, and with my duty as an engineer, have reported without reservation, according to my best judgment, the distinctive merits and demerits of the several systems proposed, and the policy which should shape the action of the Government in dealing therewith.

In closing, I desire to express to Your Excellency my most hearty thanks for the cordial assistance rendered by all with whom I have been associated during the execution of my task, hoping that the results will be of some service to the Government in its future consideration of the whole subject of internal communication for Hokkaido.

I am Sir, Very Respectfully,
Your Obedient Servant,

WM. WHEELER,
Professor of Civil Engineering,
Sapporo Agricultural College.

TEXTILE FIBRES.

BY

PROFESSOR D. P. PENHALLOW, B.S.

TEXTILE FIBRES.

The following questions are suggested as a basis for inquiry :—

1st.—What is the structure of the most important textile fibres in use, and the peculiarities by which they may be distinguished?

2nd.—What is the action of chemical reagents peculiar to each, and their quality as affected by various processes of manufacture?

3rd.—What effect do difference in food, sanitary conditions, etc., have upon the amount and quality of silk produced by different kinds of worms, and what is the nature of the diseases effecting the worms raised at Sapporo?

4th,—What are the practical relations of these considerations to the application of fibres to economical purposes?

A consideration of a few questions suggested under the above; the origin of the fibres most commonly in use; and the characteristics which distinguish them, will form the subject of the present paper.

The uses to which fibres are applied are numerous, important and well recognized, and in their application to the wants of man, indispensable. They are characterized as being the result of organized life, either animal or vegetable.

The first are distinguished either as secretions, under which are classed the threads of silk-worms and spiders, or the direct result of organized growth which includes the various kinds of vegetable fibres and wool or hair.

The last class offers by far the more numerous variations in the hairs of different species and varieties of animals, of which the sheep furnishes the greatest supply, though the goat, camel, bison and others furnish more or less valuable material.

The fibres of vegetable growth are numerous both in their origin and application, but comparatively few are used for fabrics which find a general market, the majority being limited to certain localities, or employed in the manufacture of paper, ropes, etc.

In their origin, they are distributed through a wide range of plants, and include the bast fibres and seed hairs of exogens, and the bast from the vascular tissue of endogens. Those which claim particular attention as being of general importance for textile fabrics, are Cotton and Flax, to which should be added the animal fibres Wool and Silk. In connection with these, Hemp will be considered as of local importance, and also the bark fibre or Ohiyô of the Ainos.

The value of the first four for economical purposes and in the commerce of the world needs but an allusion.

In addition to the home production, Great Britain annually imports from eighty to ninety thousand tons of flax. In 1868 there were exported from the United States, upwards of seven hundred and eighty million pounds of cotton, while the value of raw and manufactured cotton exported during the same year

amounted to over one hundred and fifty million dollars. The total valuation of the silk annually produced throughout the world, is placed at about two hundred and fifteen million dollars, that produced in Japan being estimated at seventeen millions.

In addition to their direct value for the fibres they produce, the flax, cotton and hemp plants furnish in their seeds, material which is valuable in other branches of industry, while the waste cocoons and pupas of the silk-worms seem to be prized in some portions of China, as articles of food; and the utilization of waste fibres for paper and coarse manufactures is also an important consideration in industrial economy.

The following arrangement, which is stated for further consideration, will present some of the more important features of the fibres under discussion.

		Diameter.	Length.	Character.	Structure.
	Animal.	Inches.	Inches.		
Wool	*Oris aries* ...	1/550 1/1600	1—8	Albuminoid	Compound cellular growth.
Silk	*Bombyx mori*	1/1000*	429—3,000†	Albuminoid	Solid: double secretion.
	Vegetable.				
Cotton	*Gossypium herbaceum*	1/1000 1/1600	1—3	Cellulose	Vegetable hair.
Flax	*Linum usitatissimum* ..	1/1000 1/2500	0,983 1,766	Prosenchyma	Bast.
Hemp	*Cannabis sativa*.....	1/1200 1/1600	—?	Prosenchyma	Bast.
Ohiyô	*Ulmus?*	1/2000	—?	Prosenchyma	Bast.

* Double thread. † Feet.

Where two lengths are give they represent the approximate extremes, otherwise the average.

The above table will serve as a basis for the consideration of silk and flax in regard to some of their more important features, and the remaining four with reference to their origin and distinguishing characteristics.

The fibre represented in Fig. 4, Plate 1, is the bast obtained from the bark of a tree which is very abundant in the island of Yesso, and, so far as it has been possible to decide from its general appearance, seems to be an *Ulmus* or one of a nearly allied genus. Like most bast cells, the fibres have thick walls and a small central cavity ; are quite uniform in size throughout their length, until near the extremities when they taper rapidly to a point. They are devoid of markings, with the exception of occasional thin places in the walls, and are about the two thousandth of an inch in diameter. They possess considerable strength, but in the condition in which they are found, are of a coarse, stiff nature, and impregnated with the coloring matter of the bark. Their separation is a matter of some difficulty, even with the aid of caustic alkali, and the processes to which they are subjected before weaving are not calculated to aid in their separation. The macerating is accomplished in salt water for the better quality of cloth, when the bundles of fibre are drawn from the the bark by the fingers, split to the required size and are ready for weaving. The coarser cloth, used for rainy weather and not very strong, is made of fibres which have not been macerated, but drawn from the bark after the latter has been thoroughly broken by the *teeth*. The threads of the warp are not twisted, but those of the woof are, though imperfectly.

Cloth made of this material is worn by the Ainos as their chief article of clothing, and by them called Ohiyô. It also finds favor among the Japanese of Yesso. Of late, cotton warp has been used by the Ainos though generally preferred as ornamental threads rather than as a general warp; while the cloth worn by the Japanese is made almost entirely with cotton warp and bark woof. The color of such varies from a red brown to brown according to its preparation, that which has been macerated in salt water being the lightest in color.

Hemp.

In its usual application, hemp (Fig. 3, Plate I) is recognized as the fibre of *Cannabis sativa*, but the name is applied locally in various parts of the world to fibres from very different sources, making it rather generic in its application. Thus by it are recognized the fibres obtained from representatives of the *Malvaceæ*, *Leguminosæ*, *Apocynaceæ*, *Urticaceæ*, *Liliaceæ* and *Musaceæ*, plants not only of different orders, but of different types of structural growth. The term should be considered, however, as particularly applied to *Cannabis sativa*. In form, the cells are very long, thick walled and taper gradually to a point at each end. The walls are frequently marked by thin places which are long and narrow, running transversely to the axis of the cell, and are sometimes accompanied by a thickening or contortion of the wall which gives the cell a peculiar marked appearance when examined under low powers. It occasionally happens that the markings are strong enough to bear some resemblance to flax, but

this is seldom, the majority of thin places appearing as simple transverse lines. Constrictions in the cell wall (Fig. 2, Plate III) are sometimes noticeable, but appear to be of much more frequent occurrence in specimens taken from growing plants and subjected to maceration, than in those taken from twisted hemp. Subjected to the action of boiling nitric acid, the fibres swell readily and break into fragments without the development of spirals, in the latter respect differing from flax.

Flax.

Flax has its origin in the bark of *Linum usitatissimum*, and like hemp, consists of long, thick walled bast cells, the ends of which taper very gradually to a point. Its distinguishing characteristics are, the development of a close, double striation on treating with boiling nitric acid, and the peculiar knotty appearance of many of the cells, the nature of which will be considered more carefully.

Fig. 2, Plate I, represents a portion of a flax cell showing its peculiar knotty appearance and cylindrical form. Most of the specimens from which the drawings were taken, had suffered maceration, and nearly all the cells so treated showed a well defined double striation (Fig. 1, Plate II) similar to that developed by the action of boiling nitric acid. The customary method of representing flax fibres as if consisting of several cells, and a failure to find a satisfactory explanation for so doing, led me to enquire more carefully as to their true nature. It will be seen by reference to Fig. 1, (Plate II) that the striation of the cell wall is in two directions; the

series crossing each other and the axis of the cell very obliquely. The stratification, not shown, is concentric with the cell wall and consists of circular laminæ which cross both systems of striæ in an axial direction, so that the cell wall cut in three directions, may be considered to consist of a number of parallelopipedal sections arranged in a radial manner from centre to circumference, and in a spiral manner around the cell. Seen in transverse section, striæ show as radial lines crossing the lines of stratification, and thus the appearance is presented as shown in Fig. 2, Plate II; a portion of a cell broken by treatment with nitric acid, in which the vertically oblique lines are those of striation, and the transverse, those of stratification, representing the laminæ broken at different lengths. The breakage of the cells was, in many cases, directly traceable to thin places in the cell wall, while many could not with certainty be traced to the same; one side would often break much higher than the other; sometimes the cell would break square across and again obliquely. The occurrence of transverse breakage, as shown in Fig. 2, would point either to the presence of numerous thin places, or of transverse striation, annular striæ which penetrate the interior wall from centre to circumference of the cell. That the latter are present seems evident from the transverse markings on the upper projection of the figure, which are due to the apparent separation of portions of the wall, which, however, could not be freed from each other, but maintained a constant distance, showing that they were connected more or less completely.

According to Sachs, both annular and spiral striæ may be present in different parts of the same cell; and while it is quite certain that the latter are pre-

sent, it also seems probable that the former appear at certain points. In all cases where the striation was most perfect, there were no well defined transverse markings, which, however, might have been the result of the different degrees in which the striæ were developed by maceration; often well defined transverse markings would be approached by a few striæ only, seeming to point to an absence of one where the other predominated.

Fig. 4, Plate II shows a cell, upon the outer surface of which appears a well defined annular marking. Two similar cases have been noticed though not so well marked and their occurrence on flax fibre can hardly be considered frequent. Formations on the interior of cell walls, resulting from a strictly localized deposit of material, are of frequent occurrence and recognized as rings, spikes, spirals, etc., with various modifications, according to the tendency of the deposit to be strongest at certain points over the general surface. Similar in character, but differing in position, are the external sculpturings of pollen grains, which appear as a variety of modified bands, ridges and spines, such as are found in *Cucurbita* and *Chicorium*. All cells, the walls of which are thickened, are to be considered primarily (as consisting) of a simple, thin cell wall, which by further development of the interior, increases in thickness and reduces the cell cavity, until the whole presents a more or less solid structure. The thickening is analogous to the formation of internal warts or rings, differing only in degree; the former representing a general secondary deposit throughout the extent of the cell wall, while the latter shows the formation to be localized. In the former, also, the

formation is resolved into alternately more and less dense or watery layers; which cause the whole thickening to appear as composed of laminæ. If the development of the cell wall is caused by the interposition of molecules of formative material between those of the already formed tissue, the external sculpturings are, in mode of origin, the same. In the case of the rings noticed, there were no thin places seen in connection with them, but they appeared as shown in the figure, as distinct elevations on the cell wall. Thin places in flax fibre, extending from the cavity of the cell to the outer margin or wall, are of frequent occurrence, and nearly always attended by a more or less structural appearance, as a broad or narrow band, or a broadening of the channel of its outer extremity. In Fig. 5, Plate II, the markings on the wall may be considered typical of those generally found. It is seen that the appearance is that of a band, causing the outline of the cell wall to swell on one side while on the other it is indented, and having a thin place in the centre. The view was upon the exterior of a cell, which shows in the drawing as a cylinder. On the right of the band will be noticed two lines running diagonally up and down from the thin place to the outer surface of the cell, ending at the upper and lower termination of the swell. With a deep focus the outline of the thin place was brought out most clearly, while with a high focus the broad band was most distinct, showing the latter to be clearly above the former. The extension of the thin place to near the margin at the left, shows the wall to be thin at that place, while the indentation at the same place, would also seem to point to a thin wall.

Fig. 1, Plate III, shows a portion of a cell in longitudinal section. In the lower marking, the opening on the left extends through the inner cell wall, and is not accompanied by any marking. On the right, the opening is seen to extend through the inner cell wall for about one-third the distance, when it enlarges rapidly until it reaches the outer wall. Such terminations are frequent, and that they are actual enlargements of the channels which they terminate, seems evident, not only from the amount of light allowed to pass, but also from the very significant fact that in no case have the lines of striation been seen to cross such places, but always terminate at the margins. The oblique lines therefore, seen in the marking in Fig. 5 (Plate III), represent the margin of an enlarged channel seen transversely, while the upper and lower borders of the apparent band, are the edges of the channel at their junction with the outer cell wall. The channel is long and broad, of varying length,—though none have yet been noticed to extend completely round the cell—but is gradually contracted as the interior wall develops, until the opening into the central cavity is marked only by a narrow, transverse slit. Analogous to these are the bordered pits in *Coniferæ*, which, at first large, contract with the development of the wall, until the interior opening is much smaller than the original cavity. Similar enlarged openings are to be seen in the thick walled cells of *Pteris aquilina* (Sachs), but the enlargement of the channel is towards the interior, while in the flax and cells of conifers it is the reverse.

In Fig. 6, Plate II, the markings appear as a ring with two thin places. In this case a high focus brought out the *ring* most clearly, showing it to be

above the thin place, or outside the wall. It was noticeable, however, that the outer wall of the cell extended over the whole, showing the enlargement to belong to the inner, thickening layers of the cell wall. In the upper marking in Fig. 1 (Plate III), it is noticed that the channel on the left extends to the outer wall without enlargement, while above and below the wall is thickened, due wholly perhaps to the separation of the two inner thickening layers in the latter case, but in the first can hardly be attributed wholly to that cause, the enlargement being more than the separation. The transverse lines crossing above and below the channel, are the outlines of the enlarged channel on the under side of the cell.

In hemp fibre, the thin places are frequent but as a rule devoid of markings. Exceptional cases occur in which the appearance is analogous to that of flax, so much so that they might with difficulty be distinguished if brought together; but in hemp the whole wall is sometimes thrown out as shown in Fig. 3, Plate IV. While there may be thickening of the wall about the margins of thin places, such as shown in Fig. 5, Plate II, can hardly be attributed to such a cause. The upper and lower lines are much too distinct to be produced by the amount of curvature seen, which on the left practically amounts to nothing, and its analogy to the enlarged opening seen in Fig. 1, Plate IV is much more probable. While it seems that many, and perhaps all, of the most prominent markings are due to thin places alone, it seems well to recognize the possible presence of annular thickenings and striæ.

Cotton.

Cotton (Fig. 1, Plate I) is the unicellular fibre obtained from the seeds of various species of *Gossypium*, and differs from most other vegetable fibres both in point of origin and structure. Analogous to it are the silk hairs obtained from various *Asclepias*, both originating in the fruit, as hairs upon the external tissue of the seeds.

The twisted character of the cells; the absence of the inner thickening layers of the cell wall which generally characterize bast fibres; and the flat riband like form of the cells when dry, which are devoid of structural markings; are sufficiently marked features of cotton to distinguish it from all fibres which have their origin within the tissues of plants.

Bast fibres present many features of a very similar nature in their structure, so that it often becomes a matter of difficulty to distinguish between them. This is particularly true with reference to their size, which is quite indefinite, varying from a length of two inches in all degrees less, while the diameter is equally indefinite. It is to the structural appearance of the fibres and their condition before and after treatment with reagents that particular attention should be directed. As already shown, the character of cotton is sufficiently pronounced to distinguish it from the other fibres under consideration; and flax is also well enough defined to avoid mistake in the majority of cases, though if structural markings alone be depended upon, it is liable to be identified with hemp as shown by their occasional similarity.

The following table will present the most important distinctive features of the fibres under consideration.

	Structural Appearance.	Treated with Nitric acid.
Wool.....	Margins serrated. Transverse anastomosing lines.....	
Silk	Double, structureless.....	Yellow color.
Cotton...	Cell flat, uniform, twisted. Central cavity large	Swelling.
Flax	Cell round; elongated; fusiform; central cavity small	Double striation.
	Walls thickened by internal layers. Transverse markings; thin places...	Breakage.
Hemp ...	Cell round; fusiform; central cavity small. Walls thickened by internal layers. Transverse thin places...	Breakage.
Ohiyô ...	Cell round; abruptly fusiform; central cavity small. Walls thickened by internal layers. Occasional thin places.....	Breakage.

Wool.

Wool owes its origin to sheep of such various grades, and is subject to such varying conditions of climate and the care bestowed upon them, that a great variation in the size of the hairs is a marked feature of the different qualities. Some of the finer grades varying from the one thousandth to the sixteen hundredth of an inch in diameter, while coarser kinds are as large as the one five hundred and fiftieth of an inch; the length varying with the sheep and time of cutting. Wool is easily distinguished from other fibres by its serrated margin caused by an overlapping of the scales of the outer layer, the edges of which are seen to cross the hair, giving the appearance of transverse anastomosing lines, and the wavy appearance which it usually presents.

Silk.

At the commencement of the spinning season, the silk is seen to issue from the two spinnerets of the worm as continous threads, parallel with and close to each other. There issues at the same time a semi-fluid gummy substance which surrounds the threads, and by hardening on exposure to the air, unites them as one (Fig. 5, Plate I), so that in reeling, they always come off the cocoon together but show a central line of union. The first portion of the silk, designed to attach the cocoon to some object of support, is deposited without any regularity, but as soon as the structure of the cocoon itself becomes the work of importance, the threads are found to cross each other closely, and are firmly united by the hardening of the gummy envelope. As the work progresses, the deposit becomes more compact and the threads more firmly united, while at the same time, the gummy secretion apparently increases until the innermost shell is very dense and firm, resembling, somewhat, course fibrous paper. All cocoons seem to be capable of being separated into four distinct layers, each of which is more compact as it approaches the interior, except the last which is merely a light web of silk surrounding the cavity, and somewhat separated from the rest of the cocoon, forming a cushion as it were, on which the chrysalis rests. In its semifluid state the gum coalesces, more or less, wherever two threads cross, causing irregularities of surface when the silk is wound off; the threads are often imperfectly united as shown in Fig. 3, Plate IV, and sometimes are not covered at all by the

gum : therefore regularity of outline cannot be looked for. Fig. 5, Plate IV, will show the appearance of silk as it comes from the cocoon. The portion *c* is formed by two threads crossing a third and shows how the gum flows from one thread to another. The two threads are represented to be separate, the result of breaking, to be more fully explained further on. In connection with the outer envelope, there is found more or less fatty matter, deposited irregularly in small globules, imparting to the silk more or less color. Exposure to the air causes the gummy coating to become dry and sufficiently hard to crack, presenting an appearance as in Fig. 5, Plate IV. Cold water does not effect the condition of the threads, but in warm water the gum is softened, and if the temperature be raised to the boiling point, is completely dissolved, causing a complete separation of the threads as shown in Fig. 4, Plate IV. The same thing occurs when subjected to the action of caustic alkali, but whereas the boiling water dissolves the gum without attacking the thread proper except under pressure, the alkali will dissolve both, though requiring greater strength to attack the inner thread. The varying effect of water and alkali on the two parts very naturally suggested a thought as to which would break first when subjected to a constant and uniformly increasing tension. By fastening one end of a thread to a glass slide which rested upon the upper stage of a microscope, and securing the other end to the lower stage, it was possible to notice the circumstances attending the breakage, the tension being obtained by moving the upper stage. It was noticeable that at intervals as the tension increased, a sudden movement of the thread would occur, caused

by the separation of the outer coating in which frequent cracks and openings appeared. The final break occurred so suddenly as to render it impossible to observe it, and only the result could be examined. Fig. 5, Plate IV, represents the end of a thread thus broken, showing that the filaments were completely separated; that a portion of the gummy coating was carried away from its thread at *b*; the irregular nature of the coating at *a* and *c;* and the cracks on the outer surface throughout the length of the section.

The elasticity of silk is considerable; but if the tension be maintained for a little while, the thread becomes permanently elongated; and the thread itself being much more elastic than the dry gum surrounding it, carries the latter away in sections.

The size of cocoons is very variable, as produced by different species of worms, and often the shape is also a marked feature. In the Italian (Fig. 1, Plate IV) the cocoon is large and well rounded at the ends, and of a beautiful buff color. The cocoon of the Sapporo worms represents the other extreme in size, though the shape is much the same (Fig. 2, Plate IV), while in the Chinese the ends are somewhat conical, the size being intermediate between the Sapporo and Italian.

Of the different species of silk worms, there are enumerated six of the genus Bombyx and fifteen of the genus Attacus. In the last is found the *Yama Mai*, or wild silk worm of Japan, and to the former belong the species which are important as furnishing the greatest supply of silk. The number of distinct species and varieties in Japan seems to be quite uncertain and use is made for the present of their local names.

The following is a list of the principal kinds raised at Sapporo, with the diameter and length of each thread annexed.

	Diameter.§	Length.†	Weight.‡
Italian	1/800	1365-2535	0.287
Chinese	1/714	1443-2028	0.165
Jôshiu Yellow	1/714	895-1677	0.195
Tôkiô Yellow	1/1000	1356?	0.185
Oshiu White	1/1000	1175-1599	0.177
Sapporo	1/1000	429-1560	0.110

§ Inch. † Feet. ‡ Grammes.

The measurements in length indicate the silk which is utilized for fine fabrics, to which must be added the floss and refuse for the total length of a thread. In the case of the Italian and Chinese, measurements were made of all the silk that could be unwound, and that of floss and remnant estimated to contain about six hundred feet in each kind, making the total length about thirty-one hundred and twenty-six hundred feet respectively.

The measurements of length in the above table were made at the silk factory at Sapporo, and show the extreme (?) lengths of silk capable of being unwound, and are given for further determination. The length varies greatly according to the temperature of the water in which the cocoons are immersed, and also with the length of time they have been kept. In the first case the outer layers are much less dense and the gum dissolves with greater facility than in the inner layers, which are compact; the outer silk reeling off readily at a temperature of 120° F., while

to unwind the inner silk, the temperature of the water had to be maintained at about 200° F.; the cocoons had been kept for six months. In the second case the silk will unwind readily when the cocoons are first formed, but as the gum hardens, the temperature required to dissolve it will increase as the time the cocoons are kept. The extreme difference in the length of Sapporo silk is probably due to the fact that the worms feed upon wild leaves; are raised by the farmers and subject to the influence of many conditions which properly housed worms are protected from, and in consequence, produce cocoons of very variable size and quality. In the case of the other silks, the variation was possibly, in part due to a difference in the temperature at which the worms were raised, a consideration, however, which requires more careful examination. The weights given are those of the cocoons after the chrysalis had been removed from each. It will be seen that the diameter, length of thread and weight of each cocoon correspond somewhat generally with the size of the latter, being arranged in order of size.

Diseases.

There are several diseases to which the silk-worm is subject, but the one which is most destructive is known as Muscardine, characterized by the growth of a fungus, *Botrytis Bassiana*, which covers the worm with a white down. Of the diseases which attack the worm at Sapporo, there seem to be four, which have been designated as rot, shrinkage, sudden death and solidification; the nature and origin of which, whether the result of fungoid growth or not, can

only be determined by observations upon the worms during the period of their growth the coming spring. During an examination of cocoons in February, it was noticed that the chrysalis of a Sapporo worm was covered with muscardine, while on the pupa of a Tôkiô Yellow worm was found an abundance of *Aspergillus candidus (Cook)*, a minute fungus common to decaying animal matter, so that its presence may have been wholly due to the condition of the dead pupa on which it was found. The latter however was hard and did not appear to be in any stage of active decomposition.

The means by which these diseases are transmitted from generation to generation presents an important and interesting subject for inquiry. From the minuteness of the spores, there are many ways in which a nursery once infected would be constantly troubled; the spores finding lodgement in every crack or blown about by the least current of air are ready to develop as soon as they meet with favorable conditions.

In conclusion it may be said that the strength of silk produced under different conditions, and subjected to different treatment, as well as a comparison of such with the strength of other fibres, are questions now under consideration, and will be elaborated as soon as a testing machine, now in process of construction, is completed. As opportunity offers the subject of textile fibres will be more fully considered, each subject as presented here receiving special consideration; and the present treatment of the subject is offered only as an introduction to future work.

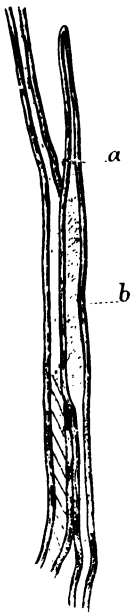
Plate I

X 100

Engraving Company Tokio. Japan.

1

2



3

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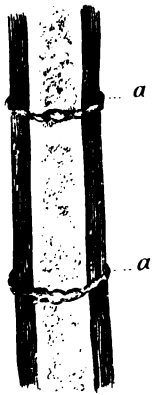

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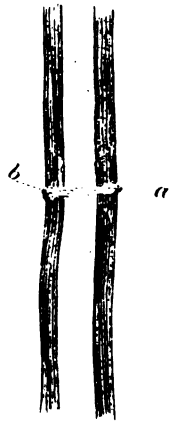

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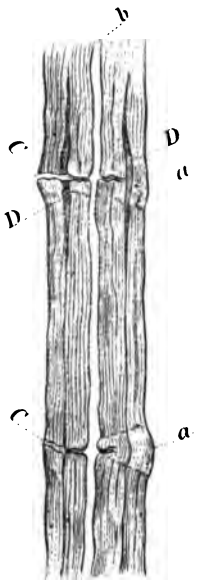
Engraving Company, Tokio Japan.



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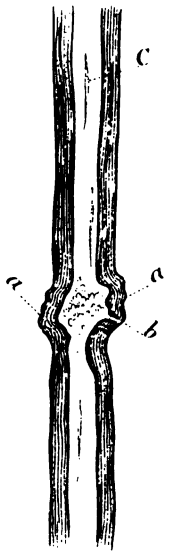


2

X 750

3

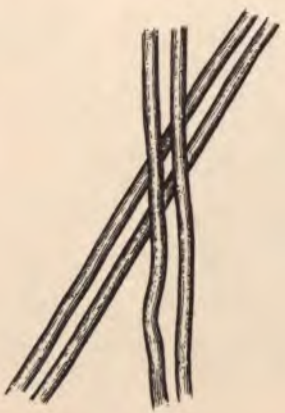
Engraving Company Tokio Japan.

1

2

X 100

3



X 100

4

X 300

5